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ENHANCING ENGINEERING EDUCATION THROUGH INDUSTRY-ACADEMIA COLLABORATION IN THE 'ENGINEERS IN SOCIETY' COURSE

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Abstract:

Engineering students frequently lack exposure to the real-world legal, ethical, and regulatory challenges they will face in their professional careers. Furthermore, the limitations of conventional classroom settings can restrict access to industry experts, hindering the delivery of contemporary and relevant knowledge. This study addresses the gap in engineering education concerning real-world legal, ethical, and regulatory challenges by integrating industry expertise into the "Engineers in Society" course through a collaborative teaching model. This study employs a mixed-methods approach, utilizing a qualitative document review to analyze the Engineers in Society course content and structure and a quantitative approach involving structured surveys to gather student feedback on learning outcomes attainment. These entrance-exit surveys include Likert-scale questions assessing students' understanding of professional and ethical responsibilities, practical application skills, and overall preparedness for engineering roles. The course content is divided into four main areas: the Malaysian Legal System, Roles and Responsibilities of Engineers, Local and Federal Authority Regulations, and the Occupational Safety and Health Act. These topics are delivered online by legal experts, industry professionals, and regulatory representatives. Results indicate significant improvements in students' comprehension of legal and regulatory frameworks and a heightened awareness of ethical considerations. The integration of industry expertise provided valuable practical insights, enriching the educational experience and offering real-world perspectives. The online format facilitated interaction with a diverse range of experts, enhancing flexibility and accessibility. The study concludes that collaborative teaching models with industry integration effectively enhance engineering education, better preparing students for future professional challenges.

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Introduction

The traditional approach to teaching engineering courses that address engineering practices to safeguard society often falls short in effectively bridging the gap between theoretical knowledge and practical application. The Engineers in Society course is specifically designed to equip engineering students with a comprehensive understanding of their professional and ethical responsibilities within the societal context. Recognizing the critical need for real-world insights, a collaborative teaching model involving industry experts has been introduced to enrich the learning experience. To further bridge the gap between theoretical knowledge and practical application, a collaborative, online educational approach is being evaluated for its impact on enhancing student preparedness. This method aligns with findings that Collaborative Online International Learning (COIL) significantly develops student outcomes across diverse competencies essential for global engineering practice (Lara-Prieto et al., 2023). Previous studies suggest that COIL programs foster intercultural competence and improve project performance compared to traditional methods (Appiah-Kubi & Annan, 2020). However, it is essential to recognize the limitations and challenges that have been observed in previous COIL implementations. For instance, disparities in technology access and digital literacy among students can hinder effective participation and engagement, particularly in diverse educational contexts. Additionally, coordinating schedules across different time zones can pose logistical challenges that may affect collaboration and communication among students and instructors. Past studies have also highlighted that while COIL enhances intercultural competence, it may not fully address the complexities of cross-cultural misunderstandings that can arise in online settings. Furthermore, the reliance on online platforms can sometimes lead to superficial interactions, where meaningful engagement is sacrificed for convenience. Addressing these challenges is crucial for maximizing the effectiveness of COIL and ensuring that it genuinely enhances student preparedness for real-world engineering challenges (Appiah-Kubi & Annan, 2020, Lara-Prieto et al., 2023).

Moreover, during periods of physical isolation, such as the COVID-19 pandemic, collaborative learning models have demonstrated their effectiveness in maintaining high levels of student engagement and learning outcomes (Chan & Zhang, 2020). These models are particularly pertinent to online software engineering education, where they address the challenges of remote collaboration and enhance learning through structured team projects (Neill, DeFranco & Sangwan, 2017). The hypothesis posits that integrating industry expertise into the "Engineers in Society" course through a collaborative, online teaching model will significantly improve engineering students' comprehension of legal, ethical, and regulatory frameworks, thereby enhancing their preparedness for professional challenges compared to traditional classroom settings. Therefore, this study seeks to understand and document the best practices of these collaborative models to maximize their educational impact in engineering courses. It also aims to evaluate the effectiveness of this approach in enhancing students' understanding and preparedness for their future roles as engineers. The core problem at hand is determining how best to structure and deliver a collaborative, online educational experience to maximize its impact on student learning outcomes. By exploring the integration of industry expertise and leveraging online collaborative models, this research aims to offer a robust framework for

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enhancing engineering education. The findings are expected to provide valuable insights for educators and policymakers in designing courses that not only impart theoretical knowledge but also ensure practical readiness and intercultural competence among engineering graduates. This approach is particularly timely and relevant as the engineering profession continues to evolve in response to global challenges and technological advancements, requiring graduates who are not only technically proficient but also socially responsible and globally aware.

Literature Review

Global demand for skilled engineers has consistently been driven by the need to address dynamic technological and socio-technological challenges. In developed countries, technology and innovation have eased societal transformations due to the availability of well-trained engineers. However, many developing countries struggle with outdated, inefficient traditional methods of technological transformation, often due to a lack of sustainable engineering education. Engineering education in developing countries needs to be restructured to enhance analytical skills, practical ingenuity, creativity in socio-technical and operational contexts, high standards of professionalism, leadership, business, and management skills. Properly trained graduate engineers with these abilities can significantly contribute to sustainable development (Shah & Gillen, 2024; Esangbedo et al., 2024).

The journey of an engineer starts from elementary science education through high school and culminates in higher education institutions, where they acquire the necessary academic background to solve real-world problems through professional and management training. However, the current engineering curricula in many developing countries are often criticized for being heavily theory-based with insufficient practical training, raising doubts about their effectiveness in producing industry-ready graduates (Shah & Gillen, 2024; Farrell et al., 2004). Enhancing sustainable engineering education in developing countries through university-industry collaboration is crucial. University education is the final stage that prepares engineers to tackle global technological changes. Developing university-industry partnerships aligns with global workforce development goals, such as those in the US and the UK, which emphasize broadening participation in STEM fields and increasing industry involvement in undergraduate education (Achebe et al., 2023; Shah & Gillen, 2024; Mejtoft et al., 2023). For instance, the University of Technology Sydney in Australia has implemented a collaborative model where students engage with industry mentors on capstone projects, significantly enhancing their employability skills and understanding of industry standards (Male, S.A., & King, R. 2019). Another noteworthy example is the Engineering Co-op Program at the University of Toronto, which integrates academic study with work experience in engineering firms. This model has demonstrated significant positive outcomes in student readiness for the workforce, as students gain hands-on experience and build professional networks during their studies (Liu et al., 2018). These case studies illustrate the effectiveness of collaborative models in engineering education, showcasing how university-industry partnerships can lead to a more practical, relevant, and sustainable educational experience for future engineers in developing countries.

Forging partnerships between industry and universities is a globally recognized strategy for achieving excellence through strategic change-making. Successful collaborations depend on several factors, including a well-established ecosystem involving academia, industry liaisons, clients, students, and faculty (Steinmo & Rasmussen, 2018; Singleton & Anderson, 2005; Shah & Gillen, 2024). Practical application of academic analysis to real-world work, translational development that makes research findings reliable and practical for industry use, effective

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planning and time constraints for both long-term and short-term projects, and mutual understanding of the research and practical application timelines are all critical to success. Despite the recognized importance of industry-academia collaboration, several challenges remain, such as the disconnection between academic research and industrial practice, reluctance of industry to implement new ideas and academia to adopt new teaching methods, lack of marketing skills among students, resource constraints for both researchers and practitioners, and trust deficits between academia and industry over the long term (Ahmed et al., 2022) (Martin et al., 2023) (Marijan & Gotlieb, 2021).

To address these challenges and enhance collaboration, several measures can be undertaken. Practical application of theoretical standards in industrial environments, initiation of internship programs, engagement of project managers from the industry to conduct lectures and share explicit knowledge, regular sharing of new research and process models between academia and industry, emphasis on industrial relevance in teaching, shared access to online resources for students and employees, international exchange programs for students and employees, and formation of committees to monitor and expand collaboration efforts are all recommended (Ahmed et al., 2022) (Crespin-Mazet & Ingemansson-Havenvid, 2021) (Ekren & Kumar, 2020). Bridging the gap between academia and industry is essential for sustainable engineering education, especially in developing countries. By implementing practical solutions and fostering long-term relationships, both sectors can work together to meet the evolving demands of the global job market and technological advancements. This collaborative approach will not only enhance the quality of engineering education but also contribute to broader socio-economic development.

Methodology

This study employs a mixed-methods approach, utilizing a qualitative document review to analyse the Engineers in Society course content and structure, which is divided into four main areas: (1) the Malaysian Legal System, where legal experts provide insights into relevant laws and regulations; (2) the Roles and Responsibilities of Engineers, Code of Ethics, and Professional Conduct, where industry professionals discuss ethical standards and real-life scenarios; (3) Local and Federal Authority Regulations, where representatives outline the regulatory landscape and best practices; and (4) the Occupational Safety and Health Act, where certified experts from DOSH, NIOSH, and CIDB discuss safety regulations and their respective organizational roles. These topics are delivered through online lectures, webinars, and interactive sessions to ensure flexibility and accessibility for students, as illustrated in Figures 1 to 5.

Complementing this qualitative analysis, a quantitative approach involving structured surveys is employed to gather student feedback on learning outcomes attainment. These entrance-exit surveys include Likert-scale questions assessing students' understanding of professional and ethical responsibilities, practical application skills, and overall preparedness for engineering roles. The survey participants comprised final year undergraduate students enrolled in the Civil Engineering program at the School of Civil Engineering, College of Engineering, Universiti Teknologi MARA, with a total sample size ranging from 130 to 200 students across three semesters: February 2023, August 2023, and February 2024. Table 1 presents the survey questions, while Table 2 describes the Likert scale used. The survey data is analyzed using descriptive and inferential statistical methods to identify trends and measure the impact of the collaborative teaching model on student learning outcomes. This comprehensive approach

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aims to document best practices and evaluate the overall effectiveness of integrating industry expertise and online collaborative learning in enhancing engineering education. At the beginning and end of the semester, students in the Engineers in Society (EIS) course participated in entrance and exit surveys.

These surveys were designed to evaluate the efficacy of the collaborative teaching model by assessing both cognitive and affective outcomes. The primary goal was to measure students' self-rated knowledge and skills related to the course outcomes before and after engaging with the course material and the collaborative teaching approach. The entrance and exit surveys included questions aimed at evaluating students' understanding of legal and regulatory frameworks, awareness of ethical considerations in professional conduct, management and entrepreneurial skills, engagement with industry professionals, and the practical application of course concepts. These questions provided a comprehensive assessment of how well the course met the Ministry of Higher Education (MOHE) learning outcomes, which focus on Values, Ethics, Moral and Professionalism, as well as Management and Entrepreneurship. However, the survey responses may be subject to potential biases, including social desirability bias, where students might provide answers, they believe are more favorable or acceptable rather than their true opinions, as well as the impact of their prior knowledge and experience, which could influence their perceptions and responses regarding the course content and its relevant to real-world engineering challenges.

Figure 1: Webinar on Occupational Safety and Health Act by Dr Mazlina Zaira Mohamad (OSHA Officer)

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Figure 2: Webinar on Uniform Building By Law (UBBL), Local and Federal Authority Regulations by Ir Mohd Rashid Ya'acob (Consultant)

Figure 3: Webinar on Code of Ethics and Professional Conduct for Engineers by Ir. Dr Jayanthi (PEPC, Consultant)

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Figure 4: Webinar on Malaysian Legal System by Pn Siti Zawiyah Abdul Zain (Lawyer)

Figure 5: Webinar on Roles of Engineering Professional Bodies by Ir Dr. Salmaliza Salleh (Academician & Consultant)

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Table 1: Entrance and Exit Survey Statements

Question Item	Statement
T-1-1	I am able to engage with the community as a prospective civil engineer in solving complex problems involving the civil engineering profession
T-1-2	I am able to contribute to the community by applying knowledge and skills learned in the classroom to help solve local problems.
T-1-3	I do understand that the Service-Learning Malaysia University for Society or known as SULAM is an initiative that provides a learning experience by integrating theory and practice to expose students to real-world problem solving in the community.
T-1-4	I do understand that SULAM is one of the important agendas in Ministry of Higher Education translated at the university level which can be considered as a noble effort by the university in producing holistic graduates by engaging them in helping the local community.
T-2-1	I understand and comprehend the ethical and professional conduct that guide a civil engineerâ€™s professional practice and service to the community.
T-2-2	I am able to adopt ethical and professional behavior that guides the professional practice and services of civil engineers to the community.
T-2-3	I do comprehend the role of engineering ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability

Table 2: Likert Scale of the Survey

Scale	Indicator
1	Strongly Disagree
2	Disagree
3	Mixed Feeling
4	Agree
5	Strongly Agree

Results and Discussion

Figures 6, 7, and 8 illustrate the average ratings from the entrance and exit surveys for the February 2023, August 2023, and February 2024 semesters, respectively. The data consistently show an increase in average ratings from the entrance to the exit surveys across all semesters. This trend indicates a positive reception of the collaborative teaching model, suggesting that students felt more knowledgeable and skilled by the end of the course compared to the beginning. Students reported significant improvements in their understanding of the practical implications of legal and regulatory frameworks, particularly in areas such as compliance with local regulations and the application of safety standards. Additionally, there was a marked increase in their awareness of ethical considerations in professional conduct, including the importance of integrity and social responsibility in engineering practice. Further analysis of the data revealed that the most substantial impact came from specific course modules that emphasized on professional ethics, which interactive discussions with industry experts have fostered deeper insights into this area. The integration of industry expertise was particularly beneficial, as students appreciated the practical insights provided by industry professionals. These insights enriched their learning experience and offered a real-world perspective on

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course topics. The online format of the course facilitated engagement with a diverse range of industry experts, allowing students to interact and seek guidance on various issues, further enhancing the educational experience.

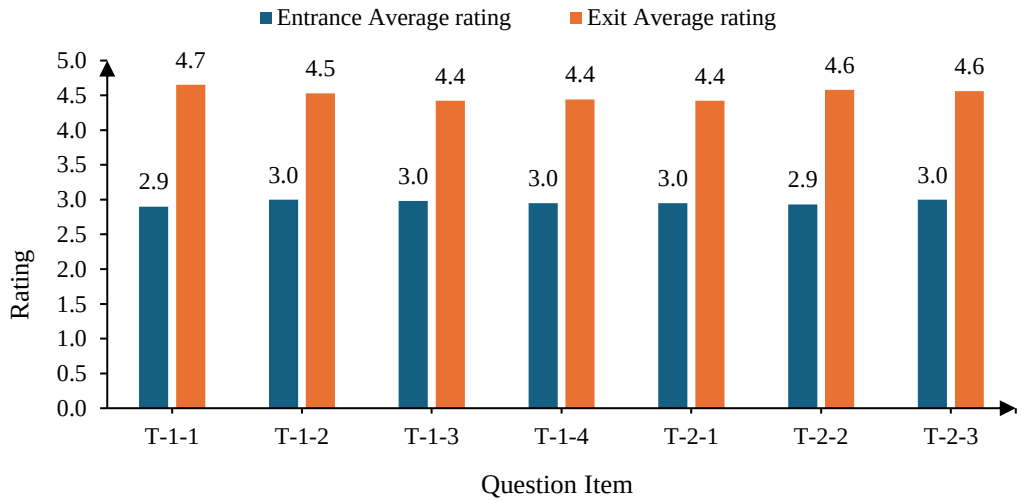

Figure 6: Average Ratings from Entrance and Exit Surveys for the February 2023 Semester

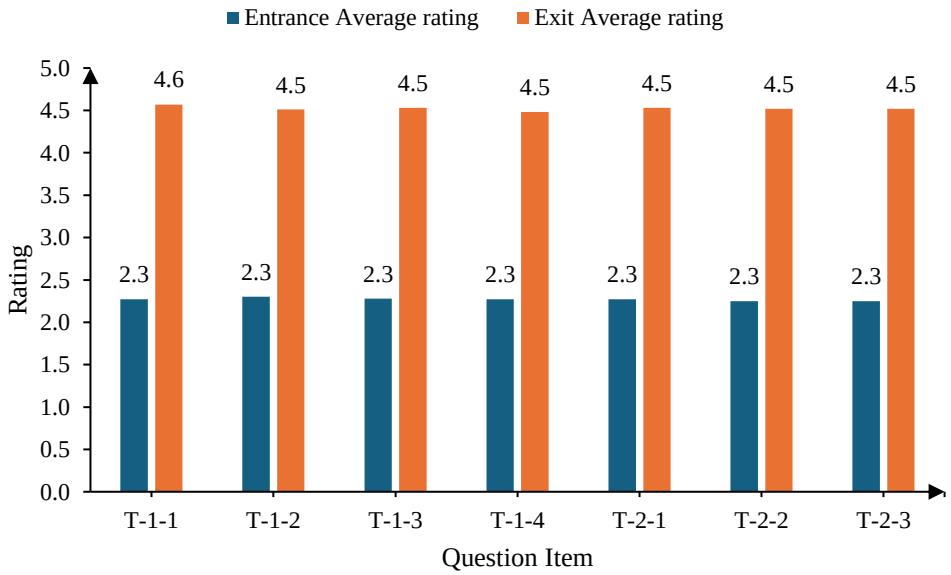

Figure 7: Average Ratings from Entrance and Exit Surveys for the August 2023 Semester

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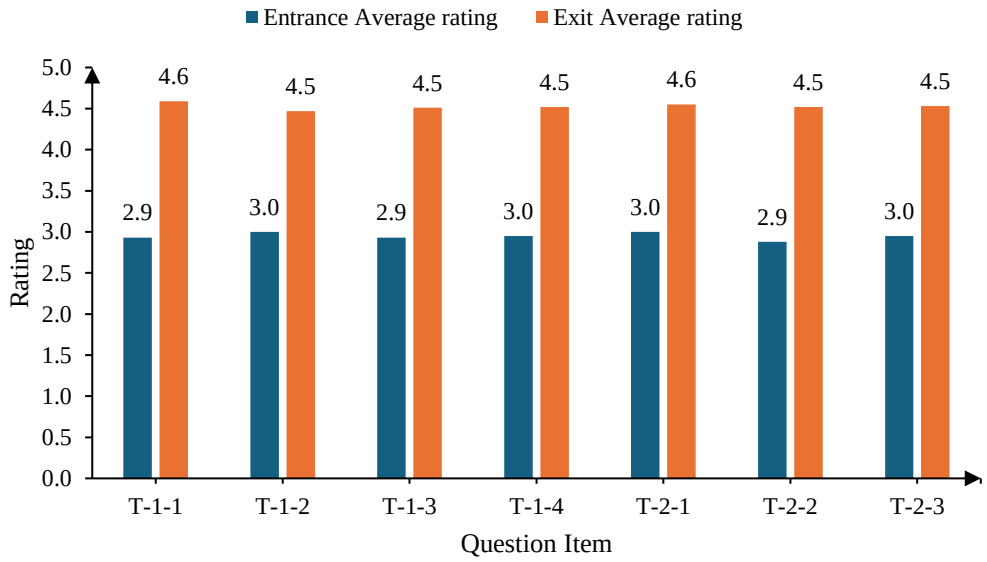

Figure 8: Average Ratings from Entrance and Exit Surveys for the February 2024 Semester

The results from the entrance and exit surveys indicate that the collaborative teaching model in the EIS course effectively enhances students' understanding and skills. The increase in average ratings from the entrance to the exit surveys demonstrates that students gained significant knowledge and practical insights, aligning well with the MOHE learning outcomes. The positive feedback from students underscores the value of integrating industry professionals into the teaching process. This partnership not only bridges the gap between theoretical knowledge and practical application but also prepares students for the complexities of the professional world. The findings of this study highlight the importance of industry-academia partnerships in engineering education. By involving industry professionals in the teaching process, students receive firsthand knowledge of current industry practices and challenges. This direct engagement enriches the curriculum, providing students with a holistic understanding of their field and better preparing them for their future careers.

Despite these positive outcomes, some challenges were noted. Scheduling conflicts between students and industry professionals were a recurring issue, making it difficult to coordinate sessions. Additionally, technological problems occasionally disrupted the smooth delivery of online sessions, impacting student engagement and the overall effectiveness of the course. To address these challenges and enhance course delivery, it is essential to explore specific issues encountered, such as internet connectivity problems and software compatibility issues. Implementing alternative scheduling options or asynchronous engagement methods could help mitigate conflicts and provide students with greater flexibility to interact with industry experts. Furthermore, investing in robust technology and dedicated support systems is vital to minimizing technical disruptions, which will ensure a more seamless online learning experience. Concrete solutions, such as establishing a technical support hotline and providing training sessions for both students and instructors on the platforms used, could further enhance the resilience of the course against technological challenges.

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The collaborative teaching model implemented in the Engineers in Society course has proven effective in enhancing students' educational experiences, as evidenced by the consistent increase in ratings from entrance to exit surveys, indicating that students perceive significant benefits from this approach. By integrating industry expertise into the curriculum, the course successfully bridges the gap between academic learning and real-world application. However, it is crucial to consider the long-term impact of this model on students' professional development. Exploring whether the improvements observed translate into long-term career success or enhanced professional competence would provide valuable insights into the sustainability of these benefits. Additionally, addressing the noted challenges will further enhance the course's effectiveness, ensuring that future students continue to reap the rewards of this innovative educational model. The positive outcomes of this study underscore the importance of industry-academia partnerships in delivering a comprehensive and practical engineering education that prepares students for the evolving demands of the profession.

Conclusion and Recommendations

The implementation of collaborative teaching in the Engineers in Society (EIS) course has significantly enhanced engineering education by integrating industry expertise into the academic curriculum. The consistent increase in student ratings from entrance to exit surveys indicates that this model effectively improves students' understanding of professional and ethical responsibilities, practical application skills, and overall preparedness for engineering roles. Students reported better comprehension of legal and regulatory frameworks, along with heightened ethical awareness. The online format facilitated diverse participation from industry experts, enriching the learning experience and providing valuable real-world insights.

Looking forward, the potential long-term impact of this collaborative teaching model on students' professional development is noteworthy; the skills and experiences gained could significantly influence their future careers in engineering. Furthermore, the success of this model in the EIS course suggests that similar approaches could be applied across other engineering disciplines and institutions, thereby broadening its positive implications for engineering education as a whole. However, logistical challenges, such as scheduling conflicts and technological issues, must be addressed to ensure seamless course delivery. To further improve the effectiveness of the collaborative teaching model in the EIS course, the following recommendations are proposed:

- Enhance Technological Infrastructure: Investing in reliable technologies, such as high-speed internet, interactive learning platforms, and comprehensive technical support systems, will minimize disruptions during online sessions. This approach will ensure a smoother and more effective learning experience for students.
- Continuous Feedback and Iteration: Regularly collecting and analyzing student and industry professional feedback will help identify areas for improvement and adapt the course content and delivery methods to better meet the needs of all participants.
- Expand Industry Partnerships: Increasing the number and diversity of industry partners within the civil engineering sector, including construction firms, environmental consultants, infrastructure developers, and liaison authorities, will provide students with a broader range of perspectives and expertise. Engaging professionals from these areas can further enrich their learning experience and facilitate valuable networking opportunities.

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Overall, this collaborative teaching approach represents a significant step towards more integrated and practical engineering education. By engaging directly with industry professionals, students gain a comprehensive view of their future careers, better preparing them for professional challenges. The positive outcomes highlight the importance of industry-academia partnerships in developing effective and comprehensive engineering education.

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