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Integrating Innovation: A Transdisciplinary Approach to Engineering Education with AI and Lean Six Sigma

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abstract

This paper proposes a novel transdisciplinary program integrating robust technical skills, entrepreneurial and management insight within the engineering discipline. The transdisciplinary program is essential as it aims to equip engineering students with technical and entrepreneurship skills that match the rapidly advancing technology space as well as the expanding engineering landscape where the technical know-how and management of the emerging technologies and the associated workforce.

The proposed transdisciplinary program incorporates diverse academic disciplines, community projects, and research initiatives to impact and nurture holistic innovation ideas among the student engineers. The program design integrates AI-driven techniques that intelligently match students with projects that align with their strengths and academic pursuits. This ensures optimized team dynamics as well as enhanced project outcomes. Additionally, students are exposed to tried and true engineering management methodologies, especially Lean Six Sigma. These methodologies instill a mindset of continuous improvement, waste reduction, and process optimization in students, which are critical skills in management and entrepreneurship.

The design of the proposed program emerged after reviewing numerous leading recent innovative programs and initiatives. Moreover, we saw the value and importance of the "Ultimate Innovation" program at the University, which supports entrepreneurial engineering projects. By merging engineering and entrepreneurship, students gain robust technical skills to be at the lead in tackling actual global challenges, incorporating effective management and entrepreneurial spirit.

This paper explores these programs' methodologies further, emphasizing the synergies achieved by combining technical education, AI interventions, and Lean Six Sigma principles. The paper advocates for an evolved paradigm in engineering education, where venture creation, technical expertise, and management excellence converge.

introduction:

Innovation in the context of undergraduate education has transformed significantly over time. This transformation has led to the creation of various programs aimed at improving human life through innovation. The landscape of engineering education faces the challenge of keeping pace with rapid technological advancements and the expanding scope of engineering roles. Traditional educational models, often classified and discipline-specific, fall short in equipping students with the necessary blend of technical, managerial, and entrepreneurial skills. This study introduces a transformative educational approach, inspired by leading innovative programs such as the "Ultimate Innovation" program at the University of Tabuk [1]. The proposed transdisciplinary program is designed to merge technical proficiency with entrepreneurial and management insight, preparing students to lead in the modern engineering landscape.

objective

The approach aims to enhance the efficiency of graduation projects in colleges for both male and female students by strengthening the relationships between colleges, research centers and chairs, developmental sectors, and companies. This goal is to ensure sustainability and foster an environment of excellence and innovation. The proposed approach draws insights from various studies, such as the integration of different engineering disciplines in biomedical education at the University of Melbourne [1], [2] , and the incorporation of transdisciplinary knowledge in first-year engineering courses [3]. This paper contributes to the field of engineering education by providing a novel approach to undergraduate learning. It showcases how the integration of Lean philosophy and continuous improvement strategies within the senior design projects can elevate the quality of engineering education. Moreover, the study highlights the practical implications of these methodologies in enhancing student performance, creativity, and employability, potentially serving as a model for future educational programs in engineering and other disciplines.

This Innovative approach will aim to:

- Raise the efficiency of graduation projects and university research centers, as the connection will provide members from various specialties
- Optimize the use of research centers' and chairs' resources and provides support opportunities for graduation projects by linking them with relevant parties.
- Multiple pathways and support opportunities from various entities are available, in addition to the possibility of working on several projects from research centers and chairs according to the project's needs.
- Develop the required skills according to the nature of the project, in addition to the skills needed in a collaborative work environment, conducted by experts in the field.

literature review

The literature review covers various studies that emphasize the importance of integrating various engineering disciplines, the role of project-based learning, and the benefits of transdisciplinary knowledge in engineering education.

A recent study [3] discuss the importance of integrating different engineering disciplines in biomedical education. Traditionally, students learn subjects like mechanics, electronics, and programming separately and this makes them miss how these subjects connect to each other. To address this challenge, the authors redesigned the curriculum at the University of Melbourne, where they designed a bionic limb. This project aims to enable students to link different subjects like programming and biomechanics and see how these pieces fit together. Their approach involves a team of academics, researchers, and designers using a design-based method to create teaching materials and a prototype limb. Although on-going, they expect this approach to reduce students' compartmentalization of knowledge hence making them better biomedical engineers.

Another study [2]. Explores the project-based learning's role in teaching interdisciplinary skills. They advocate for a curriculum at Virginia Tech that focuses on real-world problems and collaboration between different fields. They advocate for students to work closely with industry mentors and faculty to help them learn to apply their knowledge in practical ways. The author [2]. emphasize the importance of iterative design and development throughout the undergraduate program. Their model aims to enrich students' learning experiences and prepare them for complex challenges [2].

The importance of engineers working in transdisciplinary teams shows in a study [4] that explores the integration of transdisciplinary knowledge into introductory engineering education. The study emphasizes the importance of engineers working in transdisciplinary teams to tackle sustainability issues effectively. This research investigates how specific learning activities in first-year engineering courses enhance students' skills in areas like systems thinking, metacognition, and empathic thinking [4]. Researchers analyzed focus group discussions and student interviews and saw how these activities contribute to students' transdisciplinary knowledge. While earlier quantitative studies showed limited changes, a deeper qualitative analysis reveals significant improvements in students' transdisciplinary skills. This suggests that the learning activities are indeed effective in nurturing transdisciplinary thinking among engineering students.

An innovative approach been introduced to graduate education [5]. This new approach focused on transdisciplinary teamwork. The paper presents the Cohort Challenges model, which encourages graduate students to collaborate across disciplines on real-world problems [5]. These researchers claim that students gain practical experience and develop essential skills for transdisciplinary research through engagement with faculty, peer experts, and industry mentors. The study outlines the key components of Cohort Challenges and highlights the importance of team building, stakeholder engagement, and effective communication.

Another study [6]. discusses the integration of artificial intelligence into education. The paper explores the potential benefits and challenges of incorporating AI into classroom instruction. The authors argue that AI education should not be soiled but rather transdisciplinary and connect to the broader curriculum and community [6]. The paper presents a case study of an AI program developed for the Neom Community School in Saudi Arabia, where AI is integrated into the curriculum through the International Baccalaureate (IB) approach. This approach involves teaching AI both as a subject and as a tool to learn other subjects hence fostering connections across the curriculum. By embedding AI into the Units of Inquiry framework, these scholars argue that the program aims to make AI education more meaningful and interconnected with students' learning experiences.

A M3 Model used in a study [7] to explore the adoption of transdisciplinary learning experiences in universities to promote innovation. The paper introduces the M3 model, which aims to transform undergraduate learning by integrating different academic fields and fostering cross-cutting innovation skills [7]. According to scholars, the M3 model involves co-teaching and co-learning across different academic units and spans multiple semesters to encourage student learning and innovative ideas.

The University of Puerto Rico, Mayagüez Campus (UPRM) [8] introduces an initiative to establish a minor in sustainability engineering, supported by the NSF IUSE: HSI Program. The strategy in this concept is to empower a new trend of engineers with requisite skills. It is done with purpose of solving sustainability challenges using a learner-centered approach. As the paper puts it, the rationale and objectives of the program comprehensively lacks empirical evidence or data regarding the effectiveness of the proposed program. There is a gap in discussing potential challenges to implementing the transdisciplinary, learner-centered approach and strategies for fostering diversity, equity, and inclusion within the program [8].

Another study from the University of Dayton [9] brings the Stitt Scholars Program at the University of Dayton, which is designed to give experiential learning opportunities for the learners. It also offers value to entrepreneurs in the Dayton area. According to these scholars, students can perfect their communication, leadership, and problem-solving abilities and prepare them for future career success through hands-on projects. The SSP program structure enhances interaction between students, faculty mentors, and external clients hence facilitating a dynamic learning environment. This collaborative approach not only benefits students but also provides valuable support to entrepreneurs and start-up companies in the Dayton area [9]. Hence, students showcase their achievements and contribute to the program's on-going success through project presentations and participation in university events like the Stander Symposium.

While a researcher [10] explores the establishment of a novel degree program, transdisciplinary studies in engineering technology, at Purdue University. Key features of this program are; student-driven curriculum planning, extensive faculty mentoring, and a competency-based assessment framework. The TST-ET program allows students to design their own curriculum with guidance from faculty mentors and focuses on assessing their competencies. Unlike traditional engineering programs, these scholars argue that TST-ET encourages students to explore various disciplines and develop a wide range of skills. This

initiative aims to prepare students for success in the complex professional world of today and responds to the demand from employers for graduates who possess diverse abilities [10].

methodology:

program design and implementation.

The program design incorporates diverse academic disciplines and integrates real-world projects, providing a comprehensive learning experience. Key elements include AI-driven project matching and embedding Lean Six Sigma principles to provide a comprehensive learning experience.

- AI-Driven Project Matching: Utilization of AI techniques to align students with projects that suit their strengths and academic pursuits.
- Incorporation of Lean Six Sigma: Embedding Lean Six Sigma principles to instill a mindset of continuous improvement, waste reduction, and process optimization.

The, Figures 1 and 2 below show the Innovation and Entrepreneurship Center (IEC) activities and visualize the innovation process within a transdisciplinary program. Ideas originate from the University of Tabuk (UT) centers or through industry partnerships and individual contributions from students or faculty. The IEC is central to this ecosystem, acting as a hub that connects partnerships, colleges, and individuals based on the project's needs and priorities. On one side, the flowchart tracks the journey of an idea from inception to collaborative project completion. On the opposite corner, the flowchart integrates the student's senior design projects, showing them as part of the system. This comprehensive model demonstrates the pathway for an idea to mature within an academic and industrial collaborative framework.

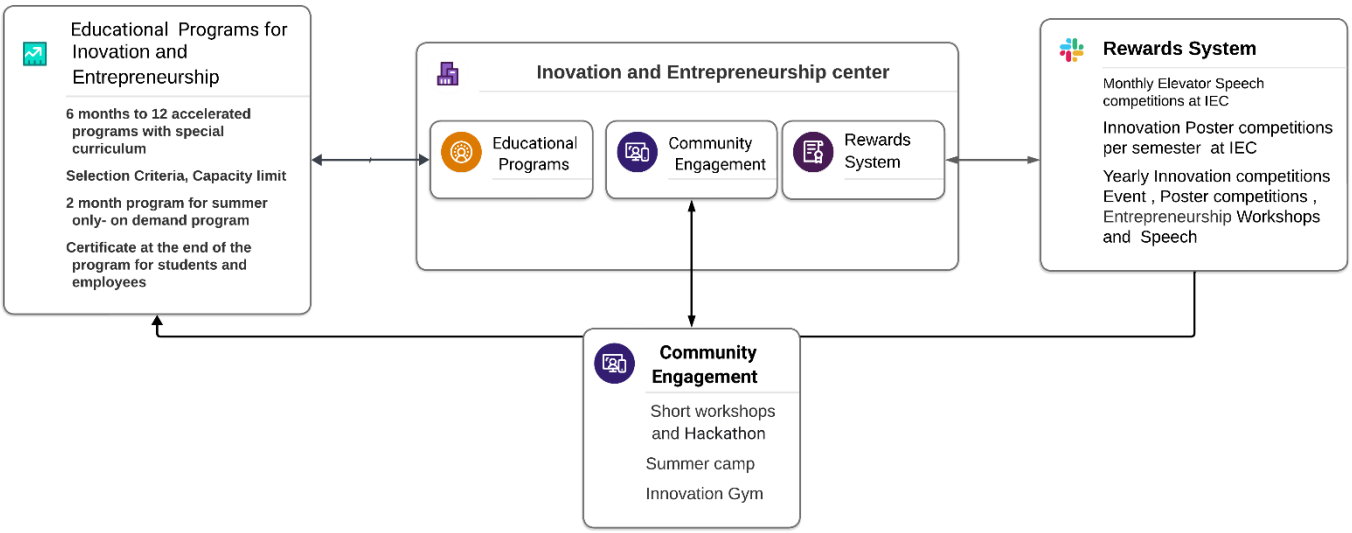

Figure 1: The IEC Activities

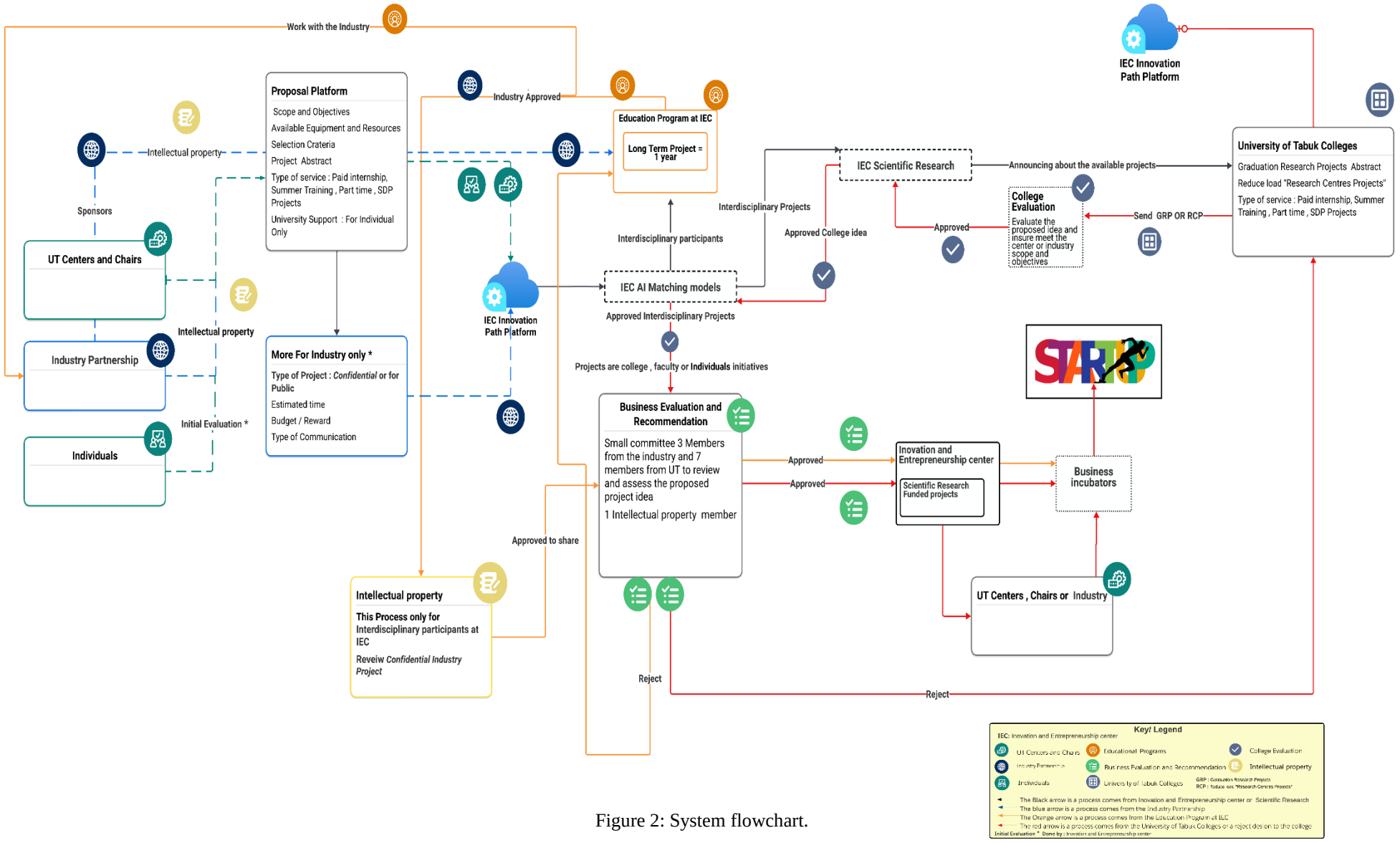

Figure 2: System flowchart.

The innovative framework presented in figure 1 and activities in figure 2 above can be described in detail, in figure 3 below:

Figure 3: The IEC platform overview.

The IEC innovative platform incorporating five distinct paths that form its backbone:

1- **Ideation from Students and Faculty (Outstanding):** This path captures the genesis of ideas, where students and faculty contribute innovative concepts based on their insights and academic pursuits.

2- **Research Centers (University Centers):** Here, university-affiliated research centers propose ideas within their domains of expertise, suggesting areas ripe for exploration and further development.

3- **Colleges (Challenging Student Projects):** Ideas are also sourced from college students' capstone projects, which are identified for their potential and challenge, providing a fertile ground for transdisciplinary research and development.

4- **University Partners (Industry Collaboration):** This entity involves ideas put forth by university partners from industry, which may require additional research or practical application to simulate projects or validate theories.

5- **Summer Training (Internships):** The final path relates to the practical experience students gain during summer internships, where they are exposed to new ideas and techniques that enhance their skills and contribute to the innovation process.

Together, these paths illustrate a holistic system where academic theory, research, practical application, and industry collaboration converge, fostering an environment where transdisciplinary approaches can thrive and lead to tangible outcomes.

Figure 4: Outstanding Path.

Figure 5: Research Centers Path

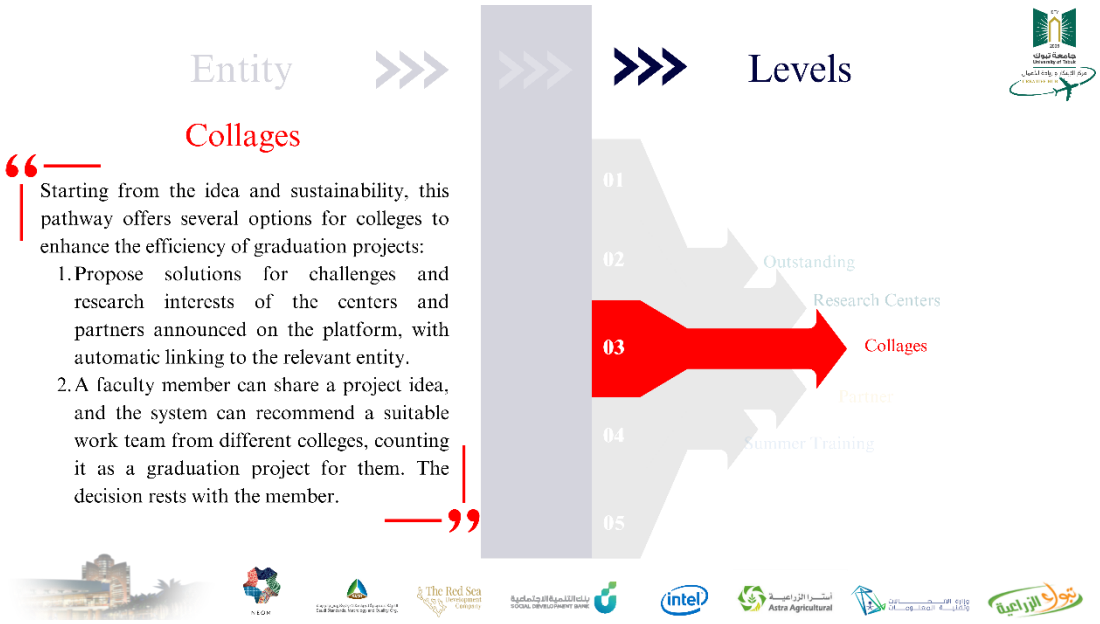

Figure 6: Collages Path

Figure 7: Partner Path

Figure 8: Summer Training Path

The IEC Platform:

The Innovation and Entrepreneurship center platform described in the figure 9 below operates through a series of interconnected stages designed to enhance the selection and development of project teams, this innovative platform utilizes AI for tailored team building and educational development, ensuring that the right skills are matched with relevant projects. This innovative platform consists of 8 steps as the following:

1- Receive Proposal: Entities submit proposals to the system. An example given is a proposal titled "The influence of accounting computer information processing technology on enterprise internal control under panel data simultaneous equation."
2- AI Analysis: An AI model analyzes these proposals to identify the necessary skills and knowledge required to accomplish the projects, suggesting the best-fit students for each.
3- Nomination System: The system nominates students for the projects, with a recommendation number indicating the ideal team size.
4- Pre-Assessment: Nominated students undergo workshops and a final assessment to ensure they possess the required skills and knowledge.
5- Group to Team: Following the pre-assessment, selected students are grouped into teams.
6- Accepted and Rejected Students: Some students are accepted and form part of the project teams, while others may be rejected.
7- Mentoring and Skill Broadening: Accepted students receive mentoring and have opportunities to broaden their skills.
8- Participation in Design Process: Students participate in multi-term projects to learn and apply the design process.

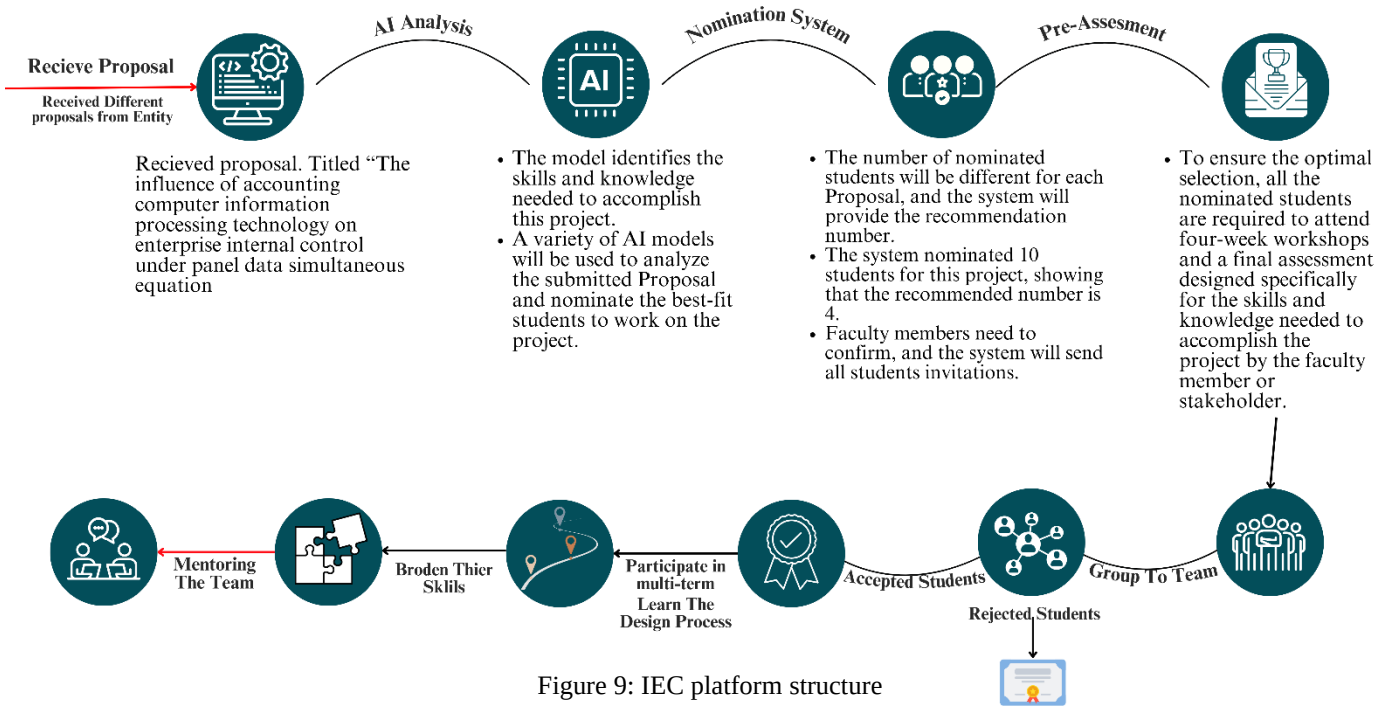

Figure 9: IEC platform structure

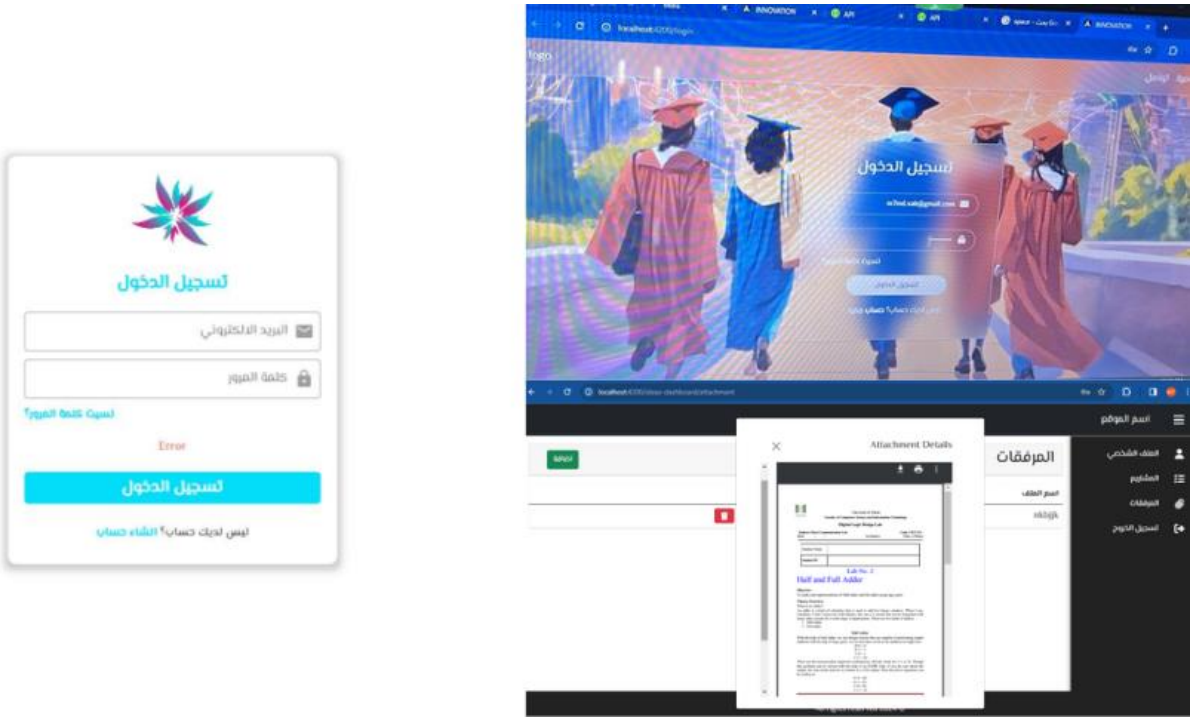

Figure 10: IEC platform

results and conclusion:

The transdisciplinary program integrating AI and Lean Six Sigma in engineering education has demonstrated remarkable success, particularly evident in three senior design projects that have significantly benefitted from this approach" Innovation Path". This innovative educational model addresses the disconnect between traditional engineering education and the dynamic demands of the modern technological and business landscapes. It positions students at the forefront of innovation, equipping them with the necessary skills to drive meaningful advancements in various sectors. These projects, each connected with the best-fit teams and partners, showcase the practical effectiveness of the program.

- **impactful Project Outcomes:** The application of the program to these projects has resulted in enhanced project efficiency and innovation. The AI-driven matching system successfully aligned projects with teams possessing the optimal skill set, ensuring that each project was tackled with expertise and creativity.

- **industry Collaboration:** The collaboration with industry partners in these projects underscores the program's ability to bridge the gap between academic learning and real-world application. This interaction has not only provided students with invaluable practical experience but has also contributed to producing tangible, impactful solutions to real-world problems.

- **enhanced Learning Experience:** These senior design projects serve as exemplary models of how this educational approach fosters a more comprehensive learning experience. Students were able to apply technical knowledge, managerial skills, and entrepreneurial thinking in a cohesive manner, demonstrating the program's effectiveness in preparing them for the complexities of the professional world.

- **setting a Precedent for Future Projects:** The success of these projects establishes a precedent for future educational initiatives. It highlights the potential of integrating AI and Lean Six Sigma in engineering education to produce graduates who are not only technically proficient but also adept in management and innovation.

These project outcomes validate the proposed educational model's effectiveness and its role in shaping a new generation of engineers. This model, by fostering a holistic approach to problem-solving and project execution, sets a new standard for engineering education that aligns with the demands of a rapidly evolving global landscape. This study not only contributes to the academic discourse on engineering education but also serves as a guide for educational institutions seeking to revolutionize their curricula. The integration of AI and Lean Six Sigma within an engineering context is a testament to the potential of interdisciplinary approaches in fostering comprehensive educational experiences that are both intellectually stimulating and practically relevant.

example of a project used the IEC platform “Case study”:

Figure 11: Case study of great team developed this application.

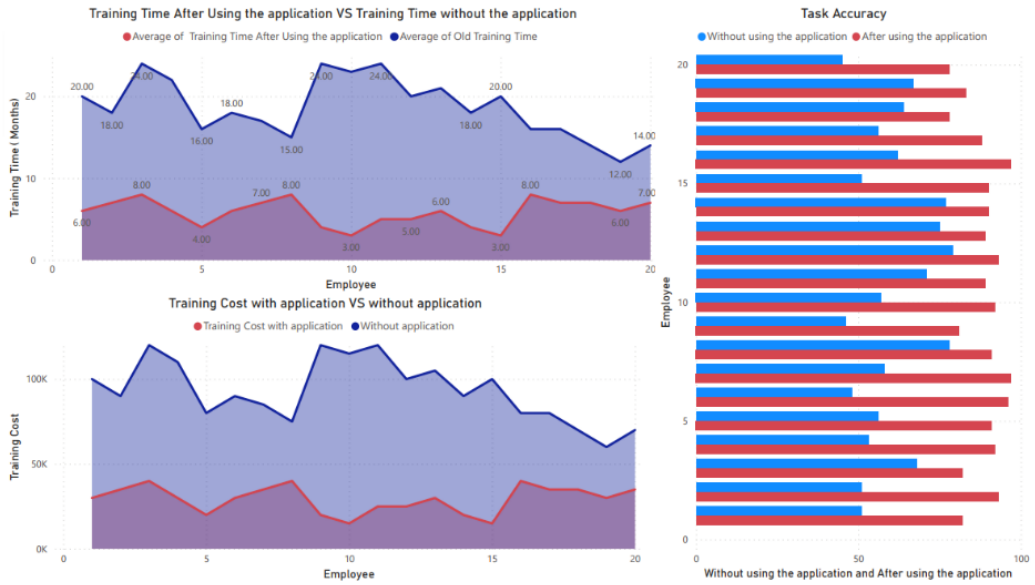

Figure 12: Case study of great team grouped by IEC platform to reach this outcome.

The IEC platform's AI-driven project matching system has proven effective with the development of a Lean and Continuous Improvement Application to boost workplace safety. The project, initiated via the outstanding path using the IEC platform by a faculty member from the University of Tabuk, rapidly assembled a diverse team, including two computer science students and a safety trainer expert, in collaboration with the Electricity Company.

The study offers a promising approach to enhancing employee knowledge and safety in industrial settings through a comprehensive application. This tool, developed from a thorough literature review on lean and continuous improvement techniques, demonstrated considerable benefits upon implementation. As illustrated in Figure 9 above, the application's introduction marked a significant advancement in training efficiency and workplace safety. Traditionally, training averaged 18.6 months, with considerable variance and substantial cost per employee. In stark contrast, with the new application, the average training duration dropped to 5.85 months, costs reduced dramatically, and task accuracy post-training surged from 60.65% to 88.6%.

These results highlight the platform's capacity to create highly skilled interdisciplinary teams and prove the design's efficiency and innovation. The project is tangible proof of concept for the platform's ability to foster meaningful collaborations that close the gap between academia and industry, thus equipping students for professional complexities.

In summary, this case study is a testament to the platform's triumph in pinpointing and grouping the appropriate skill sets for distinct projects, leading to enhanced performance, cost savings, and elevated standards of workplace safety. It exemplifies the IEC platform's role in promoting a culture of continuous improvement and efficiency within the engineering educational paradigm. The program has seen significant success, as evident in three impactful projects that effectively combine academic learning with practical application, preparing students for professional challenges.

Bibliographic Information:

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