A Multi-Tool Approach in Integrating Entrepreneurship into Engineering Technology Education

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Abstract

Engineering Technology graduates today face the challenge of mastering technical skills while also transforming innovative ideas into practical business solutions. The National Academy of Engineering highlights the importance of entrepreneurial skills for the 21st-century engineering profession. Recognizing this, there's a growing shift towards embedding entrepreneurial elements within engineering curricula to meet evolving industry demands. Despite efforts to infuse entrepreneurship into engineering education, its integration in Engineering Technology curricula specifically needs further attention. This gap highlights the need for enhancing entrepreneurship education in this field, considering the industry's demand for graduates who are both technically skilled and entrepreneurially minded. This research explores the integration of entrepreneurship into an Engineering Technology (ET) program, with a focus on a sustainable building course. It employs innovative educational strategies such as micro-moments, bisociation, virtual reality, entrepreneurial tasks, and a project-based approach to develop real-world problem-solving skills. The effectiveness of this approach was assessed through a quantitative and qualitative survey to understand student perceptions. Findings reveal students' heightened interest in innovation and entrepreneurship, improved business opportunity development skills, and an enhanced understanding of value proposition and market relevance. Quantitative data supported these insights, with a significant percentage of students reporting high satisfaction with the course's impact on their problem-solving and innovative capabilities. This curriculum enhancement contributes to job creation and economic growth across various sectors. By progressively integrating entrepreneurial thinking into their courses, ET faculty are pivotal in shaping engineers who are well-prepared to meet the complex challenges of the modern engineering landscape.

1. Introduction

Engineering Technology (ET) graduates are pivotal in driving applied innovation and are vital to the nation's infrastructure and innovation capacity, as highlighted by the National Academy of Engineering. While traditional engineering programs emphasize theoretical and conceptual training, ET education is distinctively practical and hands-on.

1.1 Engineering Technology Education: Current Challenges and Needs

The rapid advancement of technology and other industry developments necessitate graduates with skills matching the evolving occupational requirements. Accreditation Board for Engineering and Technology's (ABET) student learning outcomes for 2022-2023 highlight the necessity of applied knowledge, solution design, diverse communication skills, experimental analysis, and teamwork in technical contexts (ABET 2022). Despite being central to applied innovation, ET students often miss out on acquiring the education needed to thrive in the contemporary engineering landscape (Long, Rajabzadeh, and MacKenzie 2017). The current job market highly values transferable skills like critical thinking, problem-solving, effective communication, and the ability to work in diverse teams (Long, Rajabzadeh, and MacKenzie 2017). However, this field faces challenges: some programs struggle to keep pace with rapidly

evolving technologies, hands-on activities, and often overlook crucial skills like entrepreneurship (Che Mat, Maat, and Mohd 2015; Zhan, Wang, and Vanajakumari 2018).

Traditional trends in engineering education have often been skewed towards standard technical skills due to societal norms. This has sometimes led to a failure in recognizing the importance of evolving competencies. These challenges are compounded by factors such as faculty unfamiliarity, high technology costs, and limited resources, especially in ET programs lacking sufficient resources and faculty expertise to integrate these technologies (Çolak and Yünlü 2018). Many current ET curricula lag in incorporating these critical elements, hindered by resource constraints and a lack of faculty motivation to embrace innovative teaching methods (Matope 2021). This gap represents not only an educational deficiency but also a broader economic and societal issue. This results in a disjointed educational experience, leaving students underprepared for the multifaceted engineering challenges that require both technical proficiency and collaborative expertise.

1.2 The Necessity for Entrepreneurial Integration in ET Curricula

To address this, a shift in the educational paradigm is necessary, moving beyond traditional problem-solving to nurturing value creators skilled at navigating modern societal complexities. In accordance with ABET's criteria, ET students require a balanced mix of technical acumen and interpersonal abilities (Fosmire 2020). Although practical, hands-on learning is a focal point, the curriculum often lacks practical activities that prepare graduates to identify real-world challenges and transform technical designs into viable solutions (Bendanillo et al. 2023).

Today's industry seeks graduates who possess entrepreneurial competence and the ability to collaborate effectively in teams (Cristina 2016). This distinction highlights the necessity for graduates capable of converting innovative ideas into feasible business solutions (Sörensen et al. 2022), emphasizing a critical need for integrating entrepreneurship into engineering education. The National Academy of Engineering further reinforced this sentiment, highlighting the critical role of entrepreneurial skills in the 21st-century engineering profession (NAE 2017). In the modern engineering landscape, there is a critical need for graduates capable of transforming innovative ideas into viable business solutions, a requirement highlighted by the National Academy of Engineering's emphasis on entrepreneurial skills.

1.3 Combining Pedagogical Tools

Complementing the need for entrepreneurial acumen, virtual reality (VR) has been a transformative educational tool in engineering education. It facilitates vivid visualizations of complex concepts (Motejlek and Alpay 2023), enhancing understanding and retention (di Lanzo et al. 2020). VR-based instruction, supported by comprehensive studies and meta-analyses, can be more effective than traditional teaching methods (Yu and Xu 2022). It enables virtual collaboration beyond physical boundaries, fostering creative problem-solving through innovative tools and simulations. However, VR's educational potential is often underutilized, with a disproportionate focus on its technological aspects over pedagogical effectiveness. Aligning VR with learning-centered approaches could significantly bolster its educational impact.

Similarly, makerspaces offer dynamic environments for creativity, innovation, and hands-on learning (Soomro et al. 2023). They are crucial for ET students, providing spaces to apply theoretical knowledge practically and foster innovation (Taheri, Robbins, and Maalej 2020).

Although makerspaces have shown significant impacts on diversity, access, and retention in educational settings (Longo et al. 2017), their integration into ET curricula remains limited (Galaleldin et al. 2016). These spaces emphasize cooperative learning, making collaboration a key component of the educational experience (Yulis San Juan and Murai 2022).

Despite the individual importance of entrepreneurship, VR, and makerspaces in engineering education, there's a tendency to apply these elements independently rather than in an integrated manner. It's crucial to develop coursework or assignments that intertwine these aspects, enhancing their collective impact on engineering education. Addressing this issue, this research introduces a multi-phase project and micro-moments aimed at bridging existing gaps in ET education. By interlinking entrepreneurship, innovation, and technological expertise this research seeks to elevate the educational journey of engineering technologists. This integrated approach prepares them as well-rounded professionals, ready to contribute effectively to the workforce and meet the evolving demands of the engineering industry.

2. Background

Historically, engineering education has primarily focused on technical skills and problem-solving within a specific set of parameters. However, the contemporary professional environment demands a broader skill set. Engineering graduates today need to be equipped with the ability to identify market opportunities, understand customer needs, and develop solutions that are both technologically sound and commercially viable. This shift calls for an integration of an entrepreneurial mindset (EM) into the core of engineering education.

2.1 The Imperative for an Entrepreneurial Mindset (EM)

The concept of EM involves more than the ability to start a business. It encompasses a way of thinking that embraces innovation, risk-taking, and creativity. It's about seeing the bigger picture, identifying opportunities for improvement, and having the confidence and competence to turn ideas into reality. For ET students, this means not just learning how to design and create but also understanding the market and economic factors that drive successful engineering solutions.

The integration of an EM within core ET courses represents a significant shift from traditional educational approaches that often compartmentalize business and engineering learning. Inspired by the KEEN Framework (Blake Hylton et al. 2020), this integration embeds entrepreneurial thinking into ET education, diverging from the model of adding separate business courses. Instead, EM can be integrated into the existing curriculum through specific, strategically designed activities.

2.2 The Role of Micro-Moments in Cultivating EM

One such approach is the incorporation of "micro-moments" in lectures, are brief, interactive exercises lasting anywhere from 2 to 30 minutes (Morin and Goldberg 2022). These micro-moments are pivotal in engaging students in entrepreneurial thinking, such as recognizing opportunities, assessing impacts (Blake Hylton et al. 2020), and applying economic reasoning (Wang 2017) within the scope of engineering challenges. For example, through the analysis of case studies, students explore engineering solutions that faltered due to insufficient market understanding, emphasizing the importance of combining robust technical skills with a

nuanced grasp of market dynamics. Cultivating an EM in engineering students is instrumental in nurturing creativity, enhancing problem-solving capabilities, and developing the acumen to transform theoretical ideas into practical, marketable solutions. This approach is not just about fostering individual skills but is also crucial in equipping students to tackle the complex, multifaceted challenges prevalent in today's world.

2.3 Experiential Learning and Collaboration in EM Education

One of the key components of fostering an EM is exposing students to real-world problems and encouraging them to develop innovative solutions (Lindberg et al. 2017). This experiential learning approach bridges the gap between theoretical knowledge and practical application, ensuring that students understand the implications of their engineering solutions in a real-world context. Collaboration is another crucial aspect of entrepreneurial education. Engineering students need to learn how to work effectively in diverse teams, communicate their ideas clearly, and be receptive to feedback (Mead et al. 1999). These collaborative skills are essential in the professional world, where complex projects often require interdisciplinary teams working together to achieve a common goal.

Moreover, the integration of entrepreneurial skills into engineering curricula aligns with industry demands. Employers increasingly seek graduates who not only have strong technical skills but also possess the creativity and strategic thinking necessary to drive innovation. In response, many engineering programs are now incorporating courses and modules focused on entrepreneurship, business models, and market analysis. The benefits of this educational approach extend beyond individual career success. Engineers with entrepreneurial skills are well-positioned to contribute to economic growth and societal development. They are the ones who will create new technologies, start companies, generate jobs, and develop sustainable solutions to global challenges.

2.4 Research Questions

This study focuses on ET students and is guided by the following research questions:

(1) How do ET students perceive the importance of integrating entrepreneurial principles into their coursework?
(2) How do engineering technology students envision the role of entrepreneurial skills in shaping their future career paths and opportunities in the engineering sector?

These questions are designed to recognise students' attitudes and perceptions towards the inclusion of entrepreneurial elements in their engineering education. They aim to explore how students view the relevance and significance of these skills, especially in the context of sustainable building practices, thereby providing insights into the impact of this curricular integration on their educational and professional outlook.

3. Methods

This study used a qualitative and quantitative research approach to explore the impact of integrating entrepreneurial skills into ET education. The focus was on understanding the perspectives of ET students regarding this integration and its influence on their learning experiences and career aspirations.

3.1 Course and Sample Description

The participants consisted of n=17 undergraduate students enrolled in a sustainable building practices course. This course was chosen due to its innovative curriculum that integrates entrepreneurial concepts with engineering education. The typical student population within the ET department often includes working students who are balancing their academic pursuits with professional responsibilities, individuals who are managing their studies alongside family commitments, and senior students who are nearing the completion of their degrees. Such a varied demographic within the department is conducive to providing a wide range of viewpoints on the integration of entrepreneurial skills in education.

3.2 Intervention: Multi-Phase Design, Micro-Moments, and VR Implementation

Throughout the course, a diverse array of educational micro-moments (Vasquez et al. 2023; Morin and Goldberg 2022), brief yet impactful activities and interactions, were strategically employed to enrich the students' learning experience and instill a deep understanding of entrepreneurial concepts in an engineering context. Specifically, the intervention was structured around a multi-phase project titled "Innovate to Sustain: Transforming Building Practices for a Greener Tomorrow," which guided students through distinct phases of entrepreneurial development, from concept ideation to prototyping. Initially they were introduced to innovation and entrepreneurship concepts and tools, then they progressed to designing their sustainable solutions in VR, before moving on to physically prototyping their ideas as shown in Figure 1. The use of VR headsets in a collaborative space introduced an innovative dimension to design, allowing students to immerse themselves in realistic project environments. Guest speakers, actual entrepreneurs in the field, shared their experiences and insights, offering students a glimpse into the practical aspects of turning ideas into successful ventures. Tools like the Business Model Canvas (Murray and Scuotto, 2015) were introduced to provide a structured approach to developing and evaluating business ideas, particularly relevant to the engineering sector. Additionally, the course highlighted the university's entrepreneurial ecosystem, emphasizing its role in supporting student success and innovation. Hands-on activities such as time-limited Lego building and constructing structures with limited resources were pivotal in fostering teamwork, creativity, and problem-solving skills under constraints. Videos of successful business ideas, especially those related to sustainable buildings, were used as case studies to inspire, and educate. Furthermore, the concept of biomimicry was taught, illustrating how nature-inspired designs can lead to sustainable and innovative engineering solutions. This comprehensive approach aimed to cover all aspects of the entrepreneurial process within the engineering context.

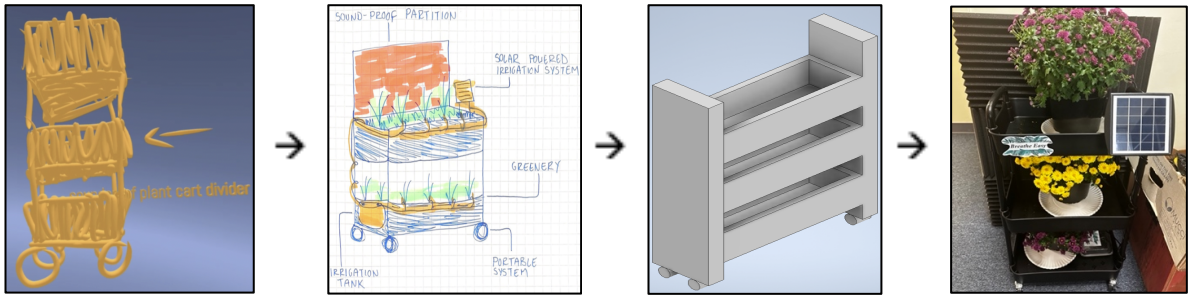

Figure 1. Phases of the project: Virtual concepts to final prototyping.

This pedagogical approach is designed to align with and address specific ABET outcomes for ET 2022-2023 for Baccalaureate degree programs. This alignment encompasses applied knowledge in mathematics and science, solution design proficiency, communication, experimental analysis, and collaboration within technical teams. Table 1 describes how each of these ABET outcomes were incorporated into the multiphase project and micro-moments approach used in this research (ABET 2022).

Table 1. An overview of ABET student outcomes and embedding entrepreneurship in ET courses.

#	Student Outcomes for Accrediting ET Programs 2022-2023	Meeting ABET Outcomes
1	An ability to **apply knowledge, techniques, skills,** and modern tools of mathematics, science, engineering, and technology to solve well-defined engineering problems appropriate to the discipline	This approach enables students to transition from theoretical knowledge to practical applications using VR for visualizing concepts and enhance virtual collaborations.
2	An ability to **design systems**, components, or processes meeting specified needs for broadly defined engineering problems appropriate to the discipline	Entrepreneurship cultivates a solution-driven mindset. Through VR, students are able to prototype and tweak designs, while makerspaces offer hands-on refinement.
3	An ability to apply written, oral, and graphical **communication** in broadly defined technical and non-technical environments; and an ability to identify and use appropriate technical literature	Effective communication is essential in entrepreneurship. The collaborative nature of makerspaces and VR environments highlights communication in technical and non-technical settings.
4	An ability to conduct standard tests, measurements, and **experiments** and to analyze and interpret the results to improve processes	This approach emphasizes iterative experimentation. With VR and makerspaces, students engage in real-time testing and learn through iterative learning.
5	An ability to function effectively as a member as well as a leader on technical **teams**	This approach prioritizes teamwork. Makerspaces foster collaboration, and VR supports remote team interactions

3.3 Instrument and Approach

The mixed methods approach used in this study combines quantitative surveys and qualitative interviews to provide a comprehensive understanding of the students' learning experiences. By integrating these methods, this research aimed to explore the strengths of both approaches: the quantitative data helped in measuring and quantifying students' perceptions and learning gains, while the qualitative data offered depth and context to these insights, for a deeper interpretation of how entrepreneurial skills impact ET education.

For this research, the instrument for assessing students' perceptions and learning gains was adapted from the Student Assessment of Learning Gains (SALG) survey (Seymour et al. 1997). The SALG tool was selected for its proven effectiveness in gathering feedback on students' perceived learning outcomes and the efficacy of teaching methods and activities. Its adaptability to various course contents made it particularly valuable for our study, allowing for a tailored evaluation of student experiences in the context of entrepreneurial skills integration in ET education. This adaptability was crucial in formulating questions that specifically

measured students' confidence in applying concepts such as life cycle assessment in green building, alongside their understanding of course content and practical integration skills.

The choice of the SALG tool and the combination of qualitative and quantitative methods were chosen to better understand the effect of the educational interventions used. The quantitative data provided a baseline measurement of learning outcomes, while the qualitative responses offered nuanced insights into the students' experiences, helping to explain the quantitative findings in greater depth. For instance, while the quantitative data might show a high level of satisfaction with the course's focus on entrepreneurial skills, the qualitative data provided stories and examples from students about how micro-moments and the multiphase project facilitated their understanding of real-world application of these skills.

3.4 Data Collection

Data was collected through a combination of open-ended questions and Likert scale questions. Students were asked to reflect on their perceptions regarding the integration of entrepreneurial skills into their ET education and its potential impact on their future careers. This approach aimed to gauge the initial attitudes and expectations of students, many of whom had not encountered entrepreneurship in their engineering coursework prior to this class. Specifically, the qualitative questions posed to students included: *"How do you perceive the importance of integrating entrepreneurial skills into ET education?" and "In what ways do you think this integration could impact your future career?"* This method of data collection was designed to capture a wide range of student experiences and perspectives, laying the groundwork for a rich qualitative analysis.

3.5 Data Analysis

To interpret the collected data, a two-phase thematic analysis was used, chosen for its flexibility and effectiveness in identifying, analyzing, and reporting patterns (themes) within the qualitative data. In the first phase, all student reflections were thoroughly examined to gain an initial understanding of the data, with initial codes generated by identifying key phrases, concepts, and patterns. These codes were then collated into potential themes, capturing the breadth of students' experiences and perceptions. In the second phase, the analysis involved a more focused re-examination of the initial themes to refine them for coherence and distinctiveness. This included a re-reading of the reflections and a careful review of the coded data to ensure that the themes accurately represented the students' perspectives. Each theme was then clearly defined and named, constructing a narrative that captured the essence of the students' experiences with the integration of entrepreneurial skills into their education.

In conjunction with the qualitative analysis, the study also incorporated a quantitative aspect to gain a more comprehensive understanding of the students' overall experiences. Responses to survey questions, collected using Likert scales, were analyzed using descriptive statistics, providing a structured quantitative analysis to complement the qualitative insights. This dual approach of combining qualitative thematic analysis with quantitative survey data facilitated a multidimensional understanding of the curriculum enhancements, highlighting the diverse impacts of integrating entrepreneurial skills into ET education.

4. Results

The results of this study encompass both the thematic analysis of qualitative data revealing six key themes. These themes collectively highlight various aspects of integrating entrepreneurial skills into engineering education. Insights from quantitative Likert scale questions were also collected. This blend of qualitative and quantitative findings offers a holistic view of how students perceive the importance of these skills for their academic and professional development, highlighting the impact of this educational approach.

4.1 Qualitative Data: Thematic Analysis of Student Reflections

Theme 1 focuses on *innovation and entrepreneurship in ET education*. The students acknowledged the critical role of innovation in sustainable building practices. They recognized the potential for innovation within the engineering sector, directly associating the course content with critical areas like sustainable construction and engineering project management. They distinguished between entrepreneurship and innovation, noting the importance of transforming creative ideas into viable business ventures. Many reflections showed a strong interest in applying innovative concepts to real-world scenarios, particularly in sustainable building. This interest reflects a desire to bridge theoretical knowledge with practical application, highlighting the relevance of the course content to their future professional endeavors. This is one of the statements the students shared: *"I believe integrating entrepreneurial skills in ET courses are crucial because the technology curriculum focuses on practical thinking."*

Theme 2 examines the *business opportunity development process* that was introduced to the students in their team projects and their entrepreneurial mindset. In their reflections, a recurring theme was the four-phase approach, which they utilized to develop their business opportunities. They emphasized that a thorough understanding of this process was crucial in transforming a business idea into reality. Additionally, students gained a deeper understanding of business models through exposure to tools like the Business Model Canvas and NABC (Needs, Approach, Benefits, and Competition) (LeBlanc and Hassan 2017) further illustrates the students' understanding of essential frameworks for structuring and evaluating business concepts, highlighting their awareness of the practical elements of business planning and development. Additionally, experiences such as pitching projects to entrepreneurs improved their communication skills, emphasizing the importance of effectively conveying ideas in the engineering field. Those are two statements: *"Other ways I utilized my entrepreneurial skills was pain-storming for the first project and thinking of ways to pitch the product to the entrepreneurs on the judge panel." "...a lot of the ET students are very creative and may have a great idea without the knowledge of how to bring it to market."*

Theme 3 centers on *value proposition and market relevance*, emphasizing students' understanding of the significance of articulating the value of a business idea and aligning it with market demands and customer needs. The students recognized the importance of a value proposition, particularly within the context of sustainability, as a key tool for articulating the worth of a business idea and making it both appealing and relevant. Additionally, their reflections emphasized the necessity of aligning business ideas with market demands and customer needs, demonstrating an awareness of the market-oriented approach vital for the success of entrepreneurial ventures. A student provided this perspective: *"The importance of*

entrepreneurial skills in engineering technology is critical. The ability to see a problem and develop an economic solution is a skill that would serve any engineer."

Theme 4 was related to students' *curiosity and further learning*. Students showed an increased awareness of the broader role engineers play in addressing global challenges such as sustainability and resource management. They recognized that engineering is a multifaceted discipline, requiring an understanding of not just technical aspects but also market dynamics, customer needs, and the environmental and societal impact of engineering work. The content and activities sparked students' curiosity about various entrepreneurial aspects, such as collaboration, competition, and market analysis, indicating a strong engagement with the subject beyond the classroom. Furthermore, several students expressed a keen interest in exploring specific topics like funding acquisition, market sizing, and the practicalities of starting a business, reflecting their motivation for continued learning and exploration in the field of entrepreneurship. An example of a student's desire for further learning: *"Learning to think like an entrepreneur is something all majors should learn, even before leaving high school, it's very useful to think about the possibility of starting your own business."*

Theme 5 focuses on *personal growth and skill development*. The course activities and projects contributed to students' personal growth, particularly in enhancing their confidence in problem-solving and developing leadership skills. The collaborative nature of the entrepreneurial activities fostered a sense of teamwork, essential for success in the engineering profession. The use of hands-on activities like Lego block building and other resources effectively simulated real-world engineering problems, enabling students to bridge the gap between theory and practice. Such activities enhanced their creative thinking skills, allowing them to explore innovative solutions, especially in sustainable building projects. Discussing their personal growth and skill development, students commented: *"This class has allowed me to dually engage with developing a product and determining basic marketing factors like demand, customer presence, and delivery." "The project was such an impactful multifaceted project that challenged me to create a unique product that enhances the sustainability of a building."*

Theme 6, *career relevance and future application*, explores how students perceive the impact of entrepreneurial skills on their future career trajectories within the ET sector. The reflections vividly illustrate a shared belief among the students that entrepreneurial skills are not just supplementary but are essential tools for broadening their career prospects. Students expressed a clear vision of how these skills could assist them in a wide array of professional roles, extending beyond traditional engineering positions. They see themselves leveraging entrepreneurial capabilities in varied capacities, from assuming management roles within established organizations to embarking on entrepreneurial ventures by starting their own engineering-focused businesses. This vision reflects an awareness of the evolving job market and the growing need for engineers who are not only technically proficient but also proficient in business and innovation. Regarding career relevance and future application of what they learned; students stated: *"This integration could impact my future career by having to come up with ways to help various companies improve efficiencies of their systems to work for the various needs of engineering disciplines." "For our specific major in civil engineering technology, I think it is very important to have an idea of what it takes to kick start a business and run with your idea or innovation."*

4.2 Word Cloud

A word cloud was created based on the thematic analysis, to provide a visual representation of the key concepts central to the research (Lohmann et al. 2015). This word cloud prominently features keywords like "Engineering," "Entrepreneurial," "Entrepreneurship," "Skills," "Thinking," "Solving," "Business," "Future," "Engineers," "Technology," "Mindset," "Professional," and "Important." These terms collectively reflect the essential themes identified in the study, illustrating the focal points of the research. Figure 2 illustrates the predominant terms derived from the thematic analysis of student reflections, highlighting the key concepts.

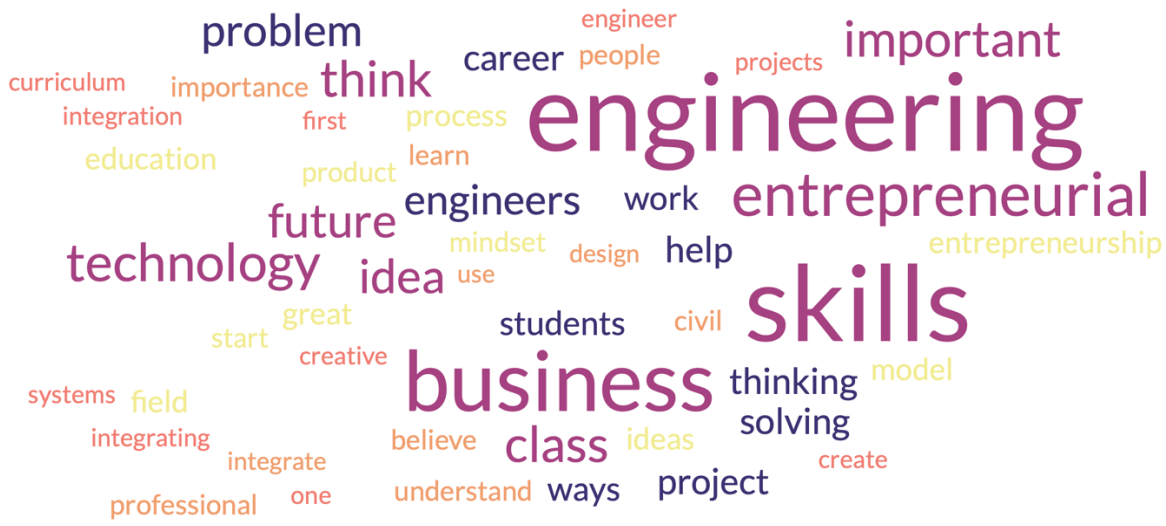

Figure 2. Word Cloud Visualization

4.3 Quantitative Data: Likert-Scale Questions

This data focused on two key questions. The first question asked, "*How satisfied are you with the influence of the entrepreneurial aspects of the course on your approach to problem solving and innovation in your project?*" The responses indicated that 88.57% of the students felt highly satisfied or satisfied with the influence of these aspects. The second question was, "*How satisfied are you with the integration of entrepreneurship principles in enhancing your understanding of sustainable building practices?*" For this question, 57.14% of students reported being extremely satisfied or satisfied, and the remaining portion remained neutral.

5. Discussion

The success of integrating entrepreneurial skills into Engineering Technology education is largely attributed to the strategic use of micro-moments and the implementation of a multi-phase project structure. These elements were fundamental in fostering a deep engagement with entrepreneurial concepts and facilitating a hands-on, iterative learning process that mirrors the entrepreneurial journey (Vasquez et al. 2023). This approach encouraged students to think beyond conventional engineering solutions, considering the business and market viability of their ideas, a shift that aligns with the thematic analysis revealing students enhanced problem-solving capabilities and a more robust entrepreneurial mindset. This eagerness to translate

classroom learning into practical applications is a positive indication of the potential for future engineers to make significant contributions to sustainable development.

Identifying the key elements for reproducing the study's results shows that the project's multiphase setup, embedded micro-moments, and targeted use of VR are all essential. Each component serves a unique purpose in cultivating a comprehensive understanding of both entrepreneurial principles and their application in ET contexts. However, it is the integration of micro-moments and the multiphase project framework, specifically, that has been effective in achieving the observed outcomes.

However, it is important to acknowledge a significant challenge in the implementation of such curricula: the readiness and ability of engineering faculty to teach entrepreneurial and soft skills. Most engineering faculty, traditionally trained in technical disciplines, may not inherently possess the entrepreneurial mindset or the pedagogical strategies required to teach these skills effectively. This gap highlights a critical area for development within academic institutions, suggesting a need for faculty development that equips educators with the knowledge and tools to integrate entrepreneurship and soft skills into their teaching.

While the focus on a sustainable buildings course provided a rich context for applying these pedagogical strategies, the foundational approach is versatile and can be adapted to other types of engineering or design education. This adaptability is key to replicating the success of this course in different educational settings, highlighting the potential for broad applicability across the engineering education spectrum.

To guide replication, educators should consider not only the individual elements but also the dynamic interaction between them. It is the combination that creates a productive learning environment, enabling students to engage deeply with the material and apply their learning in innovative ways. Furthermore, adjusting the balance of these elements to fit the context of different courses or disciplines can extend the impact of this educational model, making it a valuable addition to a wide range of curricular designs.

The results validate the positive reception of the course's entrepreneurial focus, but also provides insights for educators to tailor and improve the integration of entrepreneurship in engineering curricula. For example, this can be repeated within other faculty as they can customize their class projects to align with their teaching styles, employing methods like a project, or mini challenges for focused, short-term engagement with specific elements, or setting up discussion forums for in-depth exploration of each element. This flexibility enables them to foster innovation and entrepreneurship and adapt to various instructional methods and course structures. Additionally, it suggests a generally positive reception but also room for further enhancement in how entrepreneurial aspects influence their problem-solving and innovation skills. This suggests a broader applicability of the course design, encouraging its adaptation and adoption within various engineering and design disciplines. Overall, the responses reflect a strong appreciation for how the course's focus on entrepreneurship aided in deepening their understanding of sustainable building practices.

The prevalence of words like "thinking," "solving," and "mindset" in the word cloud highlights a shift towards innovative and holistic problem-solving approaches in engineering, where technical expertise is integrated with business understanding and entrepreneurial thought. The repetition of "skills" and "professional" aligns with the practical application of these concepts,

emphasizing the preparedness of students for diverse professional roles in technology and engineering (Thursby, Fuller, and Thursby 2009).

While many students clearly benefited and felt their skills in problem-solving, innovation, and understanding of sustainable practices were enhanced, some may require additional support or alternative teaching methods to fully grasp these concepts. The presence of neutral responses, however, indicates an opportunity for further refinement of the course structure and content to engage all students more fully. This feedback is crucial in ensuring that future iterations of the course are even more effective in equipping engineering students with the necessary skills and mindset to succeed in a rapidly evolving professional landscape.

6. Conclusion

Integrating entrepreneurial elements, including the innovative use of micro-moments, multi-phase project structures, and VR as a distinct phase, has significantly enriched the traditional ET curriculum. These methodologies equip ET students with vital skills needed to effectively contribute to both the technological and business facets of engineering projects. The skills that ET students can attain are crucial for graduates who need to contribute effectively to both the technological and business aspects of engineering projects (Litzinger et al., 2011). The ability to align engineering solutions with business strategies and market trends is crucial in today's competitive landscape and is essential for the successful implementation of engineering projects.

The results highlighted the students' recognition of the importance of entrepreneurial skills in engineering technology. They articulated clearly how entrepreneurial thinking, coupled with technical knowledge, could broaden their career opportunities, and enable them to make more meaningful contributions in their future professional roles. Additionally, they indicated a heightened interest and curiosity in exploring entrepreneurship further, particularly in the context of sustainability. This exposure has broadened the students' vision, enabling them to view sustainable building practices not just as technical challenges but also as opportunities for innovation and business development.

One key takeaway from this study is the students' appreciation of the need for engineers to possess a diverse skill set that includes business acumen, market awareness, and innovative thinking. This realization highlights a growing trend in engineering education that seeks to prepare students not just as problem solvers but as holistic thinkers capable of driving sustainable innovation and change (Ashford, 2004). These findings suggest potential benefits and are indicative of the positive impact that integrating entrepreneurship into the ET curriculum may have on student perceptions. However, it is important to acknowledge the limitations of this study, primarily its small sample size which may affect the generalizability of the findings.

Future research is needed to further investigate and validate the impacts of entrepreneurial skill integration into ET education. This could include longitudinal studies tracking the long-term career success of graduates from programs that incorporate entrepreneurial elements, as well as comparative research across different institutions to identify best practices. Additionally, it is important to explore how "micro-moments" in teaching differ from traditional active-learning techniques. With established pedagogical methods in place for decades, future

research should determine whether micro-moments offer new advantages or merely reframe old techniques. Including sensitivity analyses could further reveal the impact of varying specific pedagogical techniques, helping clarify their unique contributions to educational outcomes and potential for innovation.

Integrating entrepreneurship into ET education is not without its challenges (Abdulwahed 2017). It requires a cultural shift within academic institutions, where traditional teaching methods and curricula are revaluated and updated. Faculty members play a crucial role in this transition, as they need to embrace new teaching approaches and often step outside their comfort zones. Despite these challenges, the push towards entrepreneurial education in engineering is gaining momentum. It is being driven by the recognition that the engineers of tomorrow need to be adaptable, innovative, and ready to face the challenges of a rapidly changing world. This evolution in engineering education is not just a response to market demands, it is a necessary step in preparing students to be leaders and innovators in a world where engineering and entrepreneurship are increasingly intertwined.

In conclusion, the integration of entrepreneurial skills into ET education represents a vital step towards developing well-rounded engineers who are equipped not only with technical expertise but also with the capacity for innovative and strategic thinking. By applying micro-moments, engaging students in multi-phase projects, and leveraging VR technology, this research contributes uniquely to the discussion on ET education. It highlights the importance of a holistic view in engineering problem-solving, blending technical feasibility with market demands and user needs. Such an integrated approach is essential for addressing the challenges of modern engineering, particularly in fields like sustainable building design, which require a balance of technical, environmental, economic, and social considerations. This research contributes to the ongoing discourse on ET education and highlights the value of a more integrative and adaptive educational model for the engineers of the future.

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