
THE UNDERGRADUATE RESEARCH-STUDENT- ENTREPRENEURSHIP NEXUS: LESSONS FROM CIVIL ENGINEERING

Jacob Adedayo ADEDEJI^{*1}, Zesizwe SIBIYA¹, Nontokozo Grace
NGCOBO², Shanley HAY¹

¹*Sustainable Environment and Transportation Research Group, Department of Civil
Engineering Midlands, Durban University of Technology, Pietermaritzburg, 3201,
Republic of South Africa*

²*Innobiz DUT Centre for Entrepreneurship and Innovation, Durban University of
Technology, Durban 4001, South Africa*

**Corresponding author e-mail: jacoba@dut.ac.za*

Received 12.09.2025; accepted 29.09.2026

Abstract. The acquisition of entrepreneurial skills is increasingly critical for higher education institutions, particularly in the Global South, given the persistent rise in unemployment rates. In South Africa, unemployment reached 31.9 % as of the last quarter of 2024, with notably higher rates among university graduates. Consequently, entrepreneurship education has become a priority in government policies. However, entrepreneurship education in South African universities tends to remain theoretical, despite dedicated entrepreneurship centres. This creates a disconnect between entrepreneurship centres, students, and lecturers, thereby limiting the development of sustainable businesses. This study aimed to investigate and enhance engineering students' engagement in innovation and entrepreneurship by integrating undergraduate research with practical entrepreneurial activities. Employing a mixed-methods approach, the study combined quantitative data from questionnaire surveys and qualitative insights from workshops involving Civil Engineering Diploma students at the Durban University of Technology (DUT). The students participated in activities at Innobiz, the university's entrepreneurship centre. Additional data were gathered from secondary sources such as academic journals and institutional reports. The data were analysed via both quantitative and qualitative analysis methods to provide a comprehensive understanding of student engagement. The findings suggest that the integrating research and entrepreneurship can effectively increase students' awareness of and involvement in entrepreneurial activities. These insights could inform future educational strategies and policies to cultivate practical entrepreneurial competencies among graduates.

Keywords: *Civil engineering, entrepreneurship, graduate unemployment, innovation, undergraduate research.*

JEL Classification: L26, L31

INTRODUCTION

International appeals for a greater focus on innovation and entrepreneurship within society to foster economic advancement have prompted engineering institutions and universities to contemplate fresh educational modifications (Huang-Saad, Morton & Libarkin, 2018). This expectation is particularly relevant to engineering education because engineering graduates are increasingly required not only to solve technical problems but also to identify opportunities, develop innovative solutions and create social or economic value from their knowledge.

In South African higher education institutions (HEIs), however, entrepreneurship education (EE) is not always sufficiently integrated into disciplinary programmes. One of the major challenges is establishing transdisciplinary approaches that make EE accessible to all students and create opportunities for students from engineering, business, economics and other disciplines to collaborate in developing and implementing business ideas (Ndedi, 2013). Although many universities have established entrepreneurship centres, their activities often remain separate from formal academic curricula. This separation may theoretically result in students learning entrepreneurship while having limited opportunities to apply entrepreneurial knowledge to problems arising in their fields of study.

The concern is therefore not only whether EE is available but also how it is offered and whether the adopted educational approach produces meaningful student engagement. Lackéus (2020) argues that educators need to understand which approaches work for particular students and contexts. This remains difficult because EE includes several pedagogical approaches that are based on different understandings of entrepreneurship and do not necessarily produce the same outcomes. The challenge is greater in non-business disciplines, where entrepreneurship may be viewed as additional to the curriculum rather than as part of disciplinary learning.

According to Crişan et al. (2024), EE may be offered to non-business students either as a stand-alone course or embedded within an existing disciplinary course. Although stand-alone courses provide focused entrepreneurship knowledge, they may reinforce the separation between entrepreneurship and disciplinary practice. Embedded EE may provide a stronger connection because entrepreneurial competencies are developed while students address problems within their own fields.

Entrepreneurial education includes both entrepreneurship education, which involves learning about and through business start-ups, and enterprise education, which develops the competencies required to generate and realise ideas (Lackéus, 2020). This distinction is important because the value of EE should not be measured only by the number of businesses established by students. It should also be assessed by its ability to develop opportunity recognition, problem-solving, critical thinking, adaptability, creativity and the capacity to apply knowledge in real-world situations.

Undergraduate research provides a possible platform through which these competencies can be developed within engineering education. Undergraduate research initiatives have emerged as an important strategy for promoting

innovation, student engagement and participation in knowledge creation (Ngubane et al., 2022; Beasley et al., 2024). Rather than receiving knowledge passively, students involved in research identify problems, collect and analyse evidence, develop possible solutions and communicate their findings. These processes are closely related to entrepreneurial activity.

The relationship between undergraduate research and entrepreneurship is therefore not merely based on the possibility of commercialising research findings. It is also based on the common competencies developed through both activities. Undergraduate research provides students with opportunities to investigate real-world problems, while EE provides the knowledge and processes required to evaluate the potential value, feasibility and implementation of the solutions developed.

This integration is particularly important within science, technology, engineering and mathematics (STEM) education. Beasley et al. (2024) emphasise the role of undergraduate research in increasing diversity and participation in the STEM workforce, while Plass et al. (2024) indicate that research participation strengthens students' confidence and identities as emerging scientists. However, developing a strong STEM workforce alone may not be sufficient. There is also a need for STEM graduates who can convert technical and scientific knowledge into innovations, services and enterprises that respond to social and economic challenges.

EE is intended to equip students with the knowledge, skills and attitudes required to identify and exploit opportunities (Andalibi, 2019; Ratten & Jones, 2021). Its inclusion in engineering curricula can therefore strengthen students' ability to apply engineering knowledge beyond conventional employment settings. Browning and Bustard (2024) argue that EE allows engineering students to apply technical knowledge in real-world business situations, thereby contributing to self-employment, innovation and economic development.

Engineering education already involves problem solving, experimentation and design thinking, which are closely aligned with entrepreneurial activity. However, possessing technical problem-solving skills does not automatically mean that students can recognise the value of their solutions or develop them for implementation. EE is therefore required to help engineering students connect technical feasibility with stakeholder needs, value creation and practical application. As discussed by Crişan et al. (2024), EE develops an entrepreneurial mindset by encouraging initiative, resilience and informed risk-taking. In this study, the entrepreneurial mindset includes problem solving, opportunity recognition, critical thinking, adaptability and the ability to use knowledge in real-world circumstances. Integrating this mindset with undergraduate research may enable students to move beyond producing research reports towards considering how their findings can create value.

The aim of this study was therefore to investigate and improve the involvement of engineering students in innovation and entrepreneurship by integrating undergraduate research with entrepreneurial activities. The objectives were to evaluate the current level of awareness and engagement among engineering students regarding innovation and entrepreneurship; investigate the effectiveness of

integrating undergraduate research with entrepreneurial activities in fostering innovation among students; identify strengths and weaknesses in the relationship between entrepreneurship centres and students; and propose strategies for enhancing student involvement in entrepreneurial activities and improving the practicability of EE.

The study was designed as an exploratory study to generate preliminary insights into integrating undergraduate research and entrepreneurship within an engineering education setting.

1. LITERATURE REVIEW

1.1. Entrepreneurship Education and Entrepreneurial Development

Entrepreneurship education (EE) has become an important part of the responsibility of universities since graduate preparation cannot be reduced only to employee training. Universities should develop graduates who will be able to find opportunities, create jobs, and react innovatively to economic and social challenges. EE is concerned with developing the knowledge, attitudes and competences necessary to create value from ideas (Andalibi, 2019; Ratten & Jones, 2021). The role of EE can be evaluated in terms of its influence on entrepreneurial intention. Several empirical studies have shown that taking an entrepreneurship course increases students' intention to choose this career path (Rodríguez Gutiérrez, Pastor Pérez & Alonso Galicia, 2019; Astiana et al., 2022). However, entrepreneurial intention is not the only outcome of EE courses, since students can understand the concepts but still do not possess the necessary confidence, experience and institutional support to take action.

The impact of EE courses is related to the interaction of students' educational experience and the environment in which they live. According to Moraes, Iizuka and Pedro (2018), the characteristics of both entrepreneurship and the university environment can influence intention, while Wathanakom, Khlaisang, and Songkram (2020) showed that innovativeness is an important factor that determines students' intention to become entrepreneurs. This means that EE courses can become effective only when students have an environment in which they will be able to experiment and implement their innovative ideas. Entrepreneurial self-efficacy plays a crucial role in the discussed process. According to Adu et al. (2020) and Puni, Anlesinya, and Korsorku (2018), EE influences entrepreneurial intention by increasing students' self-confidence. The discussed finding means that simply providing students with information on entrepreneurship is not enough if they do not have any opportunity to use the received information practically. Practical activities are necessary for testing ability and gaining experience. In other words, the effectiveness of EE courses depends not only on their inclusion in the curriculum.

It is related to students' active participation in problem solving, decision making and creating value. That is why EE and entrepreneurship become particularly important for engineering education.

1.2. The Place of Entrepreneurship in Engineering Education

The conventional view is that engineering and entrepreneurship belong to different spheres, where engineering implies technical designs, whereas entrepreneurship deals with business processes. In reality, both disciplines focus on problem-solving in situations when there are no clear answers. Engineers create technical solutions to problems, and entrepreneurs establish whether these solutions can solve real problems in a sustainable way. The research conducted among engineering students proves that EE has positive effects on entrepreneurship intentions (Sun et al., 2017; Barba-Sánchez & Atienza-Sahuquillo, 2018). However, this relationship depends on the perception of entrepreneurship among engineering students because EE is perceived by them mostly through the prism of business ownership, which has nothing to do with engineering careers.

The comparative study conducted by Gilmartin et al. (2019) confirms this issue. The entrepreneurial intentions of students depend on their educational background and expectations regarding the future profession. Engineering students can have great technical and innovative abilities, but they cannot see them in terms of entrepreneurial abilities. Therefore, the task of educators is to show that entrepreneurship cannot be seen as something apart from engineering practice; it can be integral to it. This claim is supported by the findings that innovativeness, attitudes, and individual characteristics affect the entrepreneurial intentions of engineering students (Law & Breznik, 2017; Vodă & Florea, 2019). Therefore, EE among engineering students should not be limited to financial planning and business planning; it should help them identify potential in engineering problems, define stakeholders' needs, and learn how engineering solutions can bring value.

However, participation in entrepreneurship activities is limited by the structure of the programme. Shekhar and Huang-Saad (2021) claim that engineering students' engagement is influenced by programme visibility, curricular requirements, and relevance. Additional activities are mostly visited by students who are already interested in entrepreneurship, and other engineering students do not have any contact with EE. Integration of EE into engineering courses can overcome this barrier, as it connects entrepreneurship learning with the activities engineering students already conduct. Design projects, laboratory work, community projects, and research opportunities can offer the possibility for the development of entrepreneurial competencies without having to participate in an additional programme. There is an identity barrier as well. Nielsen and Gartner (2017) found that students cannot integrate the identity of a student, researcher, and entrepreneur. Therefore, engineering students may perceive entrepreneurial activities as something that does not relate to their future professional identity.

1.3. From Entrepreneurship Theory to Value Creation

One of the weaknesses of traditional EE is that it can focus heavily on explaining entrepreneurship without allowing students to experience it. Learning about entrepreneurship may develop awareness, but it does not necessarily develop the ability to act entrepreneurially. For this reason, the debate has shifted from what students should know about entrepreneurship to what students should do during the

learning process. Lackéus (2020) distinguishes between idea and artefact creation pedagogy, value-creation pedagogy and venture-creation pedagogy. These approaches differ in the level at which students move from ideas towards practical implementation. Idea creation focuses on identifying opportunities and developing possible solutions, while venture creation requires students to establish and operate an organisation.

Value-creation pedagogy occupies a useful position between these two approaches because it requires students to create something of value for others without necessarily requiring them to establish a formal business. Lackéus (2020) found that this approach had strong effects on entrepreneurial competencies, motivation, knowledge and skills acquisition. This has important implications for engineering education. Requiring every student to create a business may be unrealistic and may reduce entrepreneurship in business registration. However, requiring students to create value from engineering knowledge is closely aligned with the purpose of the discipline. Students can develop a technical solution, test it with intended users and assess its practical usefulness before deciding whether it should become a commercial or social venture.

Ratten and Usmanij (2021) therefore argue for contextual, experiential and interdisciplinary approaches to EE, while Huang-Saad et al. (2018) emphasise the need to assess both engineering and entrepreneurial outcomes. These arguments support an approach in which EE is connected to technical learning rather than added as an unrelated business component. The pedagogical issue is consequently not whether engineering students should become business students. It is whether engineering education should enable them to recognise the value of their technical knowledge and use it to respond to real needs. Undergraduate research may provide the practical environment required to achieve this.

1.4. Undergraduate Research as a Platform for Innovation

Undergraduate research has traditionally been associated with preparing students for postgraduate study and academic careers. However, its educational value extends beyond research training. It provides students with opportunities to define problems, manage uncertainty, evaluate evidence, make decisions and communicate solutions. Healey and Jenkins (2009) argue that undergraduate students should participate in research and inquiry rather than experience research only through the findings presented in textbooks and lectures. Walkington (2015) similarly positions students as active researchers who contribute to knowledge production. This changes the role of the student from a recipient of knowledge to a participant in inquiry.

The value of this participation lies partly in the confidence and disciplinary identity that students develop. Linn et al. (2015) associate undergraduate research with improved research skills, understanding and scientific identity, while Bowman and Holmes (2018) show that early research experiences can positively influence students' development. These outcomes are important because students are more likely to propose and pursue innovative ideas when they view themselves as capable contributors to their disciplines. In engineering education, research participation also provides a direct connection between theory and practice. Seifan, Lal, and

Berenjian (2022) demonstrate that undergraduate research improves learning and engagement by requiring students to apply concepts to technical problems. However, applying knowledge to a research problem is only one part of innovation. Students also need to consider who benefits from the solution, what value it provides and whether it can be implemented.

Communication forms another connection between research and entrepreneurship. Little (2020) shows that undergraduate research conferences can extend student engagement by giving students opportunities to present and defend their work. The same abilities are required when entrepreneurial ideas are communicated to users, funders, industry partners or support organisations. Undergraduate research therefore has the potential to act as more than an academic exercise. It can become a starting point for innovation when students are encouraged to move from investigating problems to considering the application and value of their findings. However, this potential may not be realised where research participation is limited to a small number of students. Stephens, Brenner, and Gentile (2017) and Haeger et al. (2020) identify challenges involving access, supervision, resources and scalability. The development of undergraduate research as a platform for entrepreneurship therefore requires institutional structures that make participation accessible and connect research activities with appropriate support.

The importance of access is further demonstrated by Beasley et al. (2024) and Plass et al. (2024), who associate undergraduate research with greater participation, confidence and retention among students in STEM. If undergraduate research provides these benefits, integrating entrepreneurial learning within such experiences may also broaden access to innovation and entrepreneurship beyond students who voluntarily join business-related programmes.

1.5. Integrating Undergraduate Research and Entrepreneurship

Undergraduate research and entrepreneurship are commonly managed as separate university activities. Research is usually located within academic departments, while entrepreneurship is supported through specialised centres, incubators or extracurricular programmes. This institutional separation may prevent students from recognising the entrepreneurial potential of their research. Despite this separation, the two activities are based on similar processes. Both begin with identifying a problem or opportunity, gathering information, evaluating alternatives and developing a response. The difference is that research commonly ends with the production of knowledge, while entrepreneurship extends the process towards the creation and implementation of value.

Burkey et al. (2019) demonstrate that technical research and entrepreneurial learning can be combined within an undergraduate engineering experience. Such integration encourages students to consider not only whether a technical solution works but also whether it responds to a genuine need and can be developed further. This does not mean that all undergraduate research must result in commercial products or businesses. Such an expectation would be unrealistic and could undermine the educational purpose of research. Rather, entrepreneurial activities

can be used to extend students' thinking about the relevance, users and practical application of their findings.

Research projects can therefore include questions relating to stakeholders, value propositions, feasibility, sustainability and implementation. These questions help students understand that technical success alone does not guarantee that a solution will be adopted or create value. The integration of undergraduate research and entrepreneurship may also strengthen entrepreneurial self-efficacy. Students who have successfully investigated a problem, generated evidence and developed a solution may be more confident in their ability to pursue innovative ideas. However, this confidence is more likely to develop when students receive opportunities to present their work, interact with stakeholders and receive support for further development.

The integration should consequently be understood as a progression plan. Undergraduate research provides the process through which problems are investigated and solutions are developed. EE provides the tools through which the value, application and sustainability of those solutions are examined. Entrepreneurship centres then provide support through mentoring, incubation, intellectual property guidance and access to networks or funding.

1.6. Institutional Support and the Curriculum–Entrepreneurship Centre Divide

Universities have established entrepreneurship centres to encourage innovation, enterprise creation and student entrepreneurship. However, the existence of a centre does not ensure that students will use its services. The centre must be visible, accessible and connected to students' academic experiences. Where entrepreneurship centres operate mainly through optional workshops and competitions, participation may be limited to students who already have business ideas or an interest in entrepreneurship. Engineering students whose ideas emerge through research or design projects may not recognise that the centre is relevant to them.

Similarly, lecturers may supervise innovative student work without having a clear process for referring promising projects for further development. Entrepreneurship-centre staff may also have limited awareness of the technical projects being undertaken within engineering departments. This creates a gap between where ideas are generated and where entrepreneurial support is provided. Shekhar and Huang-Saad (2021) show that participation is influenced by visibility, relevance and accessibility. The challenge is therefore not simply to encourage students to visit entrepreneurship centres. It is to develop an institutional pathway that connects curriculum-based projects with entrepreneurship support. Possible connections include joint project supervision, entrepreneurship-centre involvement in student research presentations, innovation exhibitions, referrals of promising projects and collaboration with industry or community stakeholders. Such arrangements would allow entrepreneurship centres to support ideas at an earlier stage and would make entrepreneurial learning more relevant to engineering students.

The central argument is that EE should not remain an isolated institutional activity. It should form part of a connected system in which academic departments help students produce knowledge and solutions, while entrepreneurship structures assist them in examining and developing the value of those solutions.

1.7. Research Gap

Existing research provides evidence that EE can influence entrepreneurial attitudes, self-efficacy and intention among university students (Sun et al., 2017; Barba-Sánchez & Atienza-Sahuquillo, 2018; Puni et al., 2018; Astiana et al., 2022). Research also shows that undergraduate research can improve student engagement, confidence, disciplinary identity and practical learning (Linn et al., 2015; Bowman & Holmes, 2018; Little, 2020; Seifan et al., 2022). However, these two areas are generally examined separately. Studies on EE commonly focus on entrepreneurial intention, attitudes or business creation, while undergraduate research studies concentrate on academic development, participation and retention. This separation provides a limited understanding of how research experiences can be intentionally used to develop entrepreneurial competencies among engineering students.

There is also limited attention to the institutional relationship between engineering departments and university entrepreneurship centres. The availability of an entrepreneurship centre does not explain whether students know about it, whether lecturers use it as a support structure or whether innovations emerging from undergraduate research are referred for further development. These gaps are particularly relevant in South African HEIs, where entrepreneurship is promoted as a response to unemployment, economic inequality and the need for innovation but may remain insufficiently embedded in disciplinary curricula.

The present study therefore investigates the integration of undergraduate research and entrepreneurial activities within engineering education. It examines student awareness and engagement, the perceived effectiveness of the proposed integration, and the strengths and weaknesses of the relationship between students and entrepreneurship centres. In doing so, the study moves beyond examining EE and undergraduate research as separate interventions and considers how they may form part of a connected approach to developing engineering students' innovation and entrepreneurial capabilities.

2. METHODOLOGY

2.1. Study Setting

This study was conducted in the Faculty of Engineering and the Built Environment (FEBE) at the Durban University of Technology (DUT) in South Africa. The focus was on the students within the 2-year Diploma in Engineering Technology in Civil Engineering and Construction Management students/graduates who have engaged with the DUT Centre for Entrepreneurship and Innovation (Innobiz) situated in the Indumiso Campus (Fig. 1). At the time of data collection for this study, a 3-year Diploma in Engineering in Civil Engineering was created.

While the formal curriculum does not explicitly integrate entrepreneurship, certain subjects and the guidance of select lecturers serve as conduits, facilitating students' engagement with Innobiz. This symbiotic relationship resonates with the framework delineated in a prior scholarly endeavour by Ngubane et al. (2022), where undergraduate research yields an assortment of co-created values. Among these, the study observed the cultivation of graduate attributes, the dissemination of scholarly publications, the inception of pioneering business concepts, and the incubation of innovative solutions.

2.2. Study Design

In the current study, a mixed-methods questionnaire was used as the main instrument for collecting the data. Two reasons for the use of such a data collection tool were as follows. First, it helped to obtain data that would be possible to analyse statistically. Second, it allowed us to obtain data that could be further explored qualitatively. The questionnaire consisted of four parts. The first part collected information about the participants' demographic background through five quantitative questions. The second part, which contained three questions, collected only quantitative data related to participants' research experience. The third part, including seven questions, was designed to explore the areas of student entrepreneurship and institutional support, where three questions were quantitative. The fourth part consisted of qualitative questions which focused only on participants' reflections related to the connection between undergraduate research and student entrepreneurship.

2.3. Population, Sampling Technique, and Data Collection

In this study, a purposive sampling approach was employed. The target population consisted of civil engineering students and alumni who had actively participated in the Innobiz initiatives within DUT. Purposive sampling is suitable when participants are selected because they have specific knowledge or experience relevant to the study (Palinkas et al., 2015; Etikan, Musa & Alkassim, 2016). A total of twelve eligible participants were identified from the Innobiz records. As the full accessible population was small, all twelve individuals were invited to participate in the study through email and telephone calls. Data collection is of utmost importance in research because the data serve the purpose of enhancing the understanding of the theoretical framework under investigation (Etikan, Musa & Alkassim, 2016). Consent was sought after a full explanation of the purpose and conditions of the study, including voluntary participation and full anonymity. In line with ethical clearance number IREC 151/21, the questionnaire was designed not to collect identifying information, and no questions required participants to provide personal details, as shown in Fig. 1.

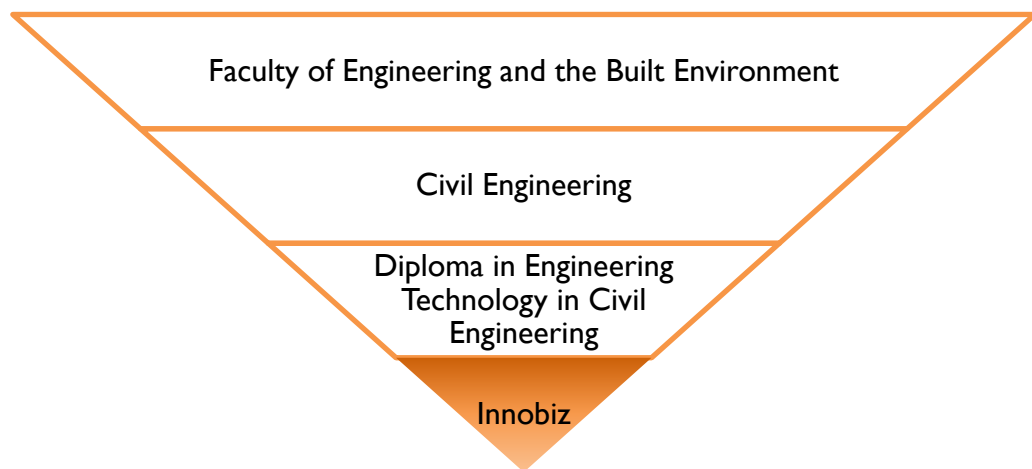


Fig. 1. Conceptualisation of the study population depicted by the brown tip of the triangle

Of the twelve individuals invited, eight responded and consented to participate, representing a response rate of 66.7 %. The link to the online questionnaire was sent via email, and participants were informed that they could choose not to participate or withdraw from the study without providing reasons. Data collection took place between March and July 2023. The final sample of eight participants represented most of the accessible population and was considered appropriate for generating preliminary insights in this exploratory study. However, the small and context-specific sample limits the reliability, scalability and generalizability of the findings. The results should therefore be interpreted as preliminary and should not be considered representative of all civil engineering students at DUT or students at other institutions.

Possible bias may have resulted from the purposive sampling approach, voluntary participation and the inclusion of only students who had participated in Innobiz. Purposive sampling does not provide every member of the wider student population with an equal opportunity to participate and may therefore limit representativeness (Etikan, Musa & Alkassim, 2016). Non-response and self-selection bias may also have occurred because the views of the four individuals who did not participate may differ from those who responded. Self-selection in online questionnaires can influence the composition of the final sample and the conclusions drawn from the responses (Bethlehem, 2010). These limitations were considered when interpreting the findings.

2.4. Data Analysis

The grounded theory method (GTM) was used to analyse the qualitative data. GTM was chosen because it is appropriate for exploratory research that seeks to elicit ideas directly from participant experiences. GTM enables iterative coding and theme development without imposing pre-existing theoretical limits, making it ideal for investigating the burgeoning convergence of undergraduate research and business. The coding method enables a progressive and verifiable mechanism for

establishing codes, their origins, relationships with each other, and integration, resulting in themes used to construct meaning (Fig. 2).

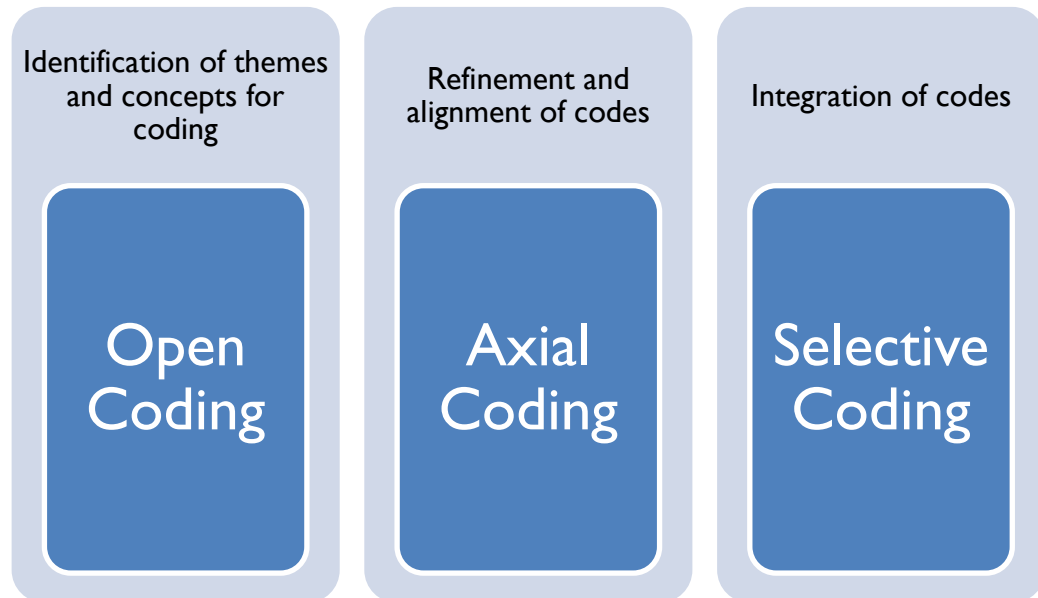


Fig. 2. Grounded theory method

3. RESULTS

Eight civil engineering students involved with the Innobiz Centre for Entrepreneurship were interviewed for this study. The respondents' ages ranged from 19 to 44 years, with 75 % falling within the 19–24 age bracket. Half of the participants were male, and the other half were female. The majority (63 %) were graduates of the 280-diploma program in civil engineering, while 25 % were currently in semester 4, and 12.5 % in semester 3 (Table 1). All participants were enrolled in the civil engineering program, and 75 % identified themselves as entrepreneurs.

Table 1. Respondent Demography

Student respondent	Gender	Age	Study level	View of self as an entrepreneur	Intro to UR research
SR1	Female	19–24	Graduate	No	Lecturer
SR2	Male	19–24	Graduate	Yes	Lecturer
SR3	Male	19–24	S3	Yes	Personal
SR4	Male	19–24	Graduate	Yes	Lecturer
SR5	Female	19–24	S4	Yes	Lecturer
SR6	Female	19–24	S4	Yes	Personal
SR7	Female	25–34	Graduate	Yes	Lecturer
SR8	Male	35–44	Graduate	No	Never

Most students reported becoming involved in undergraduate research either through a lecturer's recommendation or via module assessments, such as assignments or projects. A smaller proportion (25 %) pursued undergraduate research on the basis of personal interest. Additionally, the majority of the participants acknowledged the importance of undergraduate research in enhancing entrepreneurial skills and expressed interest in commercialising their research findings or ideas. Overall, 63 % of the respondents were still actively engaged in entrepreneurial activities, and 88 % agreed that undergraduate research experiences contributed to developing an entrepreneurial mindset.

Open-ended responses from the online questionnaire were analysed to develop codes and categories. Four themes emerged from the transcripts (Fig. 3):

- benefits of combining undergraduate research and student entrepreneurship;
- barriers to integrating undergraduate research and student entrepreneurship;
- continuity in the entrepreneurship journey;
- student-proposed suggestions for enhancement.

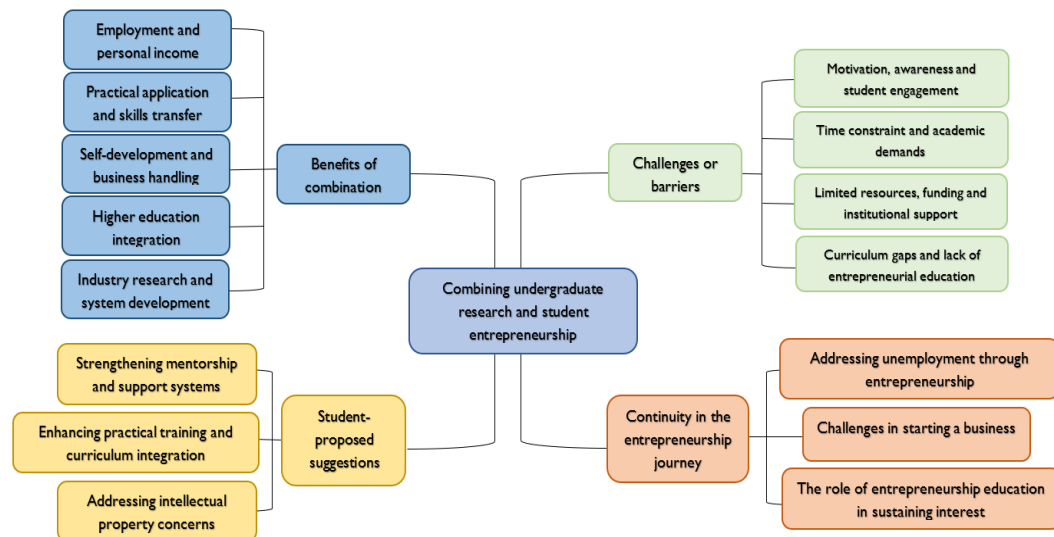


Fig. 3. Overview of themes and subthemes.

These themes collectively aim to explore the factors influencing engineering students' engagement in innovation and entrepreneurship by integrating undergraduate research with entrepreneurial activities.

3.1. Theme 1. Benefits of Combining Undergraduate Research and Student Entrepreneurship: Practical Application and Skills Transfer

Three of the participants felt that combining undergraduate research and entrepreneurship promoted students' ability in terms of applying theoretical knowledge to real-life contexts. The students indicated that engaging in research enhanced their problem-solving skills and helped them implement classroom knowledge in entrepreneurial ventures. Their views are given below.

“Gaining experience in practical applications of knowledge improved problem-solving skills. Innovation and networking opportunities.” (SR 2)

“One key benefit of combining undergraduate research and student entrepreneurship is the opportunity to explore innovative ideas and develop critical thinking skills... where students can identify market gaps and develop unique solutions.” (SR 4)

“The skillset learned from actively doing any formal research is transferable to entrepreneurship... Such attributes are integral to any successful entrepreneur.” (SR 8)

These responses reveal that undergraduate research was viewed not only as an academic activity but also as a means for developing problem-solving, critical-thinking and opportunity-recognition skills that could be applied in entrepreneurial ventures. This finding supports the view that combining technical knowledge with opportunity recognition and value creation develops entrepreneurial-minded learning among engineering students (Ngubane, Hay & Adedeji, 2022; Park et al., 2020).

Self-Development and Business Handling

A participant further highlighted how involvement in undergraduate research and entrepreneurship contributed to personal growth, increased self-awareness, and improved business management skills. The participants expressed a greater sense of purpose and confidence in their entrepreneurial journeys.

“It makes you develop your thinking and know what you want to do... I have learned more things while I am an undergraduate student, so I am focusing on my studies with my business...” (SR 3)

The findings show that integration may strengthen students' confidence, self-awareness and ability to manage competing responsibilities. These attributes are important for future leadership and venture management (Mathushan, 2020; Avrithi & Clagett, 2024). In this case, however, the development was already taking place while the participant was managing a business during undergraduate studies.

Higher Education Integration

Two participants viewed the integration of undergraduate research and entrepreneurship into higher education as important preparation for entrepreneurial activities after graduation.

“Incorporating undergraduate research and student entrepreneurship into higher education programmes can provide significant benefits to students.” (SR 4)

“I think it will assist you should you wish to be an entrepreneur postgraduation.” (SR 1)

The finding suggests that entrepreneurial preparation should form part of undergraduate education rather than be introduced only after graduation or through optional activities. Embedding entrepreneurship within research and project-based learning can connect entrepreneurial competencies directly to students' disciplinary knowledge (Woodcock, Shekhar & Huang-Saad, 2019).

Employment and Personal Income

The combination of research and entrepreneurship was also linked to improved employment prospects and the generation of personal income. Two participants viewed their entrepreneurial ventures as a means to reduce the challenges of unemployment.

“I believe that the key benefit is to be able to have your own business that will help with some personal income or investment...” (SR 6)

“It highlighted the importance of my qualification and how to use it... for entrepreneurial opportunities.” (SR 5)

This suggests that students viewed their engineering qualifications not only as a pathway to formal employment but also as a resource for creating income-generating opportunities. This is particularly relevant in the South African context, where entrepreneurship is increasingly considered a response to graduate unemployment and limited employment opportunities (Nsahlai et al., 2020).

Industry Research and Systems Development

One participant emphasised the potential of using undergraduate research to develop systems and services that could benefit the industry. Such research-driven innovations could lead to scalable business ideas with industry applications. The participant clarified:

“Unless a student can use this to develop a system... and sell that system or monitoring devices... They could develop their own consulting agency or company...” (SR 7)

This finding shows that undergraduate research may provide a pathway from identifying an engineering problem to developing an industry-relevant product or service. It therefore extends beyond general skills development by demonstrating how academic inquiry may lead to commercially viable innovations and new engineering enterprises (Gambheer & Acharya, 2024). Overall, the findings show that participants viewed the integration of undergraduate research and entrepreneurship as a means of applying engineering knowledge, developing entrepreneurial competencies and creating employment, income and industry-relevant innovations.

3.2. Theme 2. Barriers to Integrating Undergraduate Research and Student Entrepreneurship

Time Constraints and Academic Demands

The most mentioned challenge was the difficulty students faced in managing time between demanding academic responsibilities and their entrepreneurial pursuits. The responses reveal that students may be interested in entrepreneurship but prioritise completing their academic requirements. This finding suggests that entrepreneurship activities offered outside the curriculum may compete with students' academic workload, limiting sustained participation. This supports the need to embed entrepreneurship within existing research and academic activities

rather than treating it solely as an additional responsibility (Ngubane et al., 2022; Avrithi & Clagett, 2024).

“Time as in as much as you want to work on being a successful entrepreneur but passing all your modules is just as important.” (SR 1)

“Not having enough time to fully pursue student entrepreneurship.” (SR 5)

“Balancing school work and being an entrepreneur.” (SR 6)

Limited Resources and Institutional Support

Limited resources, particularly funding and institutional support, were identified as significant barriers, and it is worth noting that the effort of institutional support, such as Innobiz, was acknowledged. Nevertheless, students often struggle to access the financial resources needed to bring their ideas to life, even when they receive entrepreneurship training or mentorship.

“Right now I have a lack of funding, but I've done training at Incubation DUT Innobiz; that is my challenge now...” (SR 3)

“Limited resources, lack of awareness from the students...” (SR 2)

The findings show that training and incubation support do not necessarily enable students to implement their ideas when access to funding and other resources remains limited. They also reveal that institutional support may exist without being sufficiently visible or accessible to students. This indicates a need for stronger links between entrepreneurship centres, academic departments and student research projects (Ngubane et al., 2022; Avrithi & Clagett, 2024).

Curriculum Gaps and Lack of Entrepreneurial Education

Participants identified gaps between the formal curriculum and the research and entrepreneurial competencies required to develop student ideas.

“There is a need for in-depth research and concrete data on undergraduate students’ entrepreneurship... making entrepreneurship education compulsory for all students.” (SR 4)

“Lack of flexibility in the coursework... Most students can't even reference to save their lives, let alone read an entire science article and understand it.” (SR 7)

These responses reveal two related curriculum weaknesses: limited exposure to entrepreneurship and inadequate research competence among some students. The finding suggests that integrating research and entrepreneurship requires more than adding business content. Students also need foundational research, information literacy and critical reading skills to identify problems and develop evidence-based solutions. Embedded entrepreneurship education may provide a means of developing these competencies within engineering programmes (João & Silva, 2020).

Motivation, awareness, and student engagement

A further barrier was the limited interest of some students and lecturers in activities requiring long-term commitment.

“Garnering enough interest in the two spheres in today's world where people want instant gratification and an easy path to success.” (SR 8)

The finding suggests that low engagement may result partly from students' expectations of immediate outcomes, whereas research and venture development require sustained effort. Increasing awareness alone may therefore be insufficient. Students may require mentoring, visible role models and opportunities to observe how undergraduate ideas progress into practical or commercial outcomes (Ngubane et al., 2022; Avrithi & Clagett, 2024).

Overall, the findings show that integration is constrained by competing academic demands, limited funding and awareness, curriculum gaps and weak sustained engagement. These barriers suggest that undergraduate research and entrepreneurship should be supported through a coordinated curriculum and institutional system rather than through isolated or optional activities.

3.3. Theme 3. Student-Proposed Suggestions for Enhancement

Strengthening Mentorship and Support Systems

Mentorship was seen not only as a motivational tool but also as a bridge between idea development and implementation, helping students refine and execute their entrepreneurial concepts more effectively. The participants emphasised the need for consistent and meaningful mentorship throughout their entrepreneurial and research journey. While some acknowledged the presence of platforms such as innovation hubs and, in the case of DUT, Innobiz, they felt that these initiatives often lacked proactive, sustained engagement.

"Check-ups from our mentors would encourage us more to pursue our ideas throughout the semester." (SR 5)

"The innovation hub could offer actual support, not just listen to your idea." (SR 1)

The findings show that students expect mentorship to extend beyond initial advice or idea presentation. They require regular follow-up and practical support to help refine and implement their ideas. Although platforms such as Innobiz are available, the responses suggest that sustained engagement is needed to bridge the gap between idea development and implementation.

Enhancing Practical Training and Curriculum Integration

Two participants advocated for more hands-on training opportunities and practical exposure aligned with their specific business interests. This includes sector-based practicals and the integration of entrepreneurial content into the engineering curriculum. SR3 explained:

"...to give us more training, either we go to our sectors of business, do practical so that we can see if we know how to do that business." (SR 3)

SR8 further clarified:

"Be more visible and include such info even during lectures. Students need to hear real-world applications in the class so as to fuel the interest." (SR 8)

The findings show that students require sector-specific practical exposure rather than entrepreneurship being taught only in theory. They also suggest that including real-world entrepreneurial applications in lectures may increase

awareness and interest. Embedding practical entrepreneurship into engineering education can therefore strengthen students' skills and connect academic knowledge with business opportunities (João & Silva, 2020; Yan et al., 2021).

Addressing Intellectual Property Concerns

One participant raised concerns about intellectual property when undergraduate research produces ideas with commercial potential.

“Strong base of intellectual property concern...” (SR 2)

This response suggests that uncertainty about the ownership and protection of student innovations may discourage students from developing or sharing their ideas. Although institutional policies may be available, clearer guidance on intellectual property ownership, protection and commercialisation rights is required to support research-driven entrepreneurship.

Overall, the findings show that students proposed sustained mentorship, practical curriculum-based training and clearer intellectual property guidance as important measures for improving the integration of undergraduate research and entrepreneurship.

3.4. Theme 4. Continuity in Entrepreneurship Journey

Addressing Unemployment Through Entrepreneurship

Two participants viewed entrepreneurship as a pathway to self-employment and broader social upliftment.

“I want to help support entrepreneurship for all individuals, even those who don't have exposure to such resources our institution offers.” (SR 4)

“I believe that I can better people's lives and I also benefit from it by networking.” (SR 6)

The findings show that their motivation extended beyond personal income to creating opportunities and improving the lives of others. This socially driven motivation may support continuity in entrepreneurship because students view enterprise development as both a personal and societal contribution. This aligns with the broader role of university entrepreneurship education in supporting entrepreneurship development and strengthening students' entrepreneurial intentions within the Sub-Saharan African context (Hasan, Khan & Nabi, 2017; Puni, Anlesinya & Korsorku, 2018).

Challenges in Starting a Business

Not all students see themselves as business founders. Some feel more confident in managerial or analytical roles within existing ventures rather than initiating new startups. This self-awareness influences how they envision their entrepreneurial future.

“I see myself as more of a manager of an existing business rather than having the creative spark to start my own thing. I am much more adept at evaluating data and making the strategic move based on risks.” (SR 8)

This finding shows that students may identify with different entrepreneurial roles. While some may prefer establishing new ventures, others may contribute through management, analysis and strategic decision-making. This reflects the multiple identities associated with student entrepreneurship and suggests that entrepreneurship programmes should not focus only on venture founders (Nielsen & Gartner, 2017). Differences in personality, educational background and career expectations may also influence how engineering students position themselves within entrepreneurial activities (Gilmartin et al., 2019; Vodă & Florea, 2019).

Entrepreneurship Education in Sustaining Interest

A participant noted that a lack of formal education in his desired industry limited his ability to progress with his business ideas. Continued development and access to EEs tailored to their field were seen as critical factors in overcoming stagnation and moving beyond the ideation phase.

“The industry I'd like to be an entrepreneur in is not easy to be part of if you did not study it, hence why I'm stuck in the idea phase two years later.” (SR 1)

This response suggests that entrepreneurial interest alone may not be sufficient to sustain progress. Students also require industry-specific knowledge, practical exposure and continued support to move from idea development to implementation. Entrepreneurship education is more likely to sustain participation when it is relevant to students' disciplines and provides opportunities for practical engagement (Shekhar & Huang-Saad, 2021; Ratten & Usmanij, 2021). In engineering, such support may strengthen entrepreneurial intention by connecting technical knowledge with realistic venture opportunities (Sun et al., 2017; Barba-Sánchez & Atienza-Sahuquillo, 2018).

Overall, the findings show that continuity in student entrepreneurship is shaped by social and economic motivation, students' different entrepreneurial identities, and access to relevant disciplinary knowledge and institutional support.

4. DISCUSSION

This study investigated the integration of undergraduate research and entrepreneurship among civil engineering students at DUT, with a focus on how such integration can foster innovation and entrepreneurial skill development and ultimately enhance job readiness. Based on Lackéus' (2020) value-creation pedagogy (VaCP), this integration may help students learn through the creation of value for others.

As discussed earlier in the literature review, the results of the study are consistent with other researchers who argue that undergraduate research experience can enhance innovation, student engagement and participation in STEM disciplines (Ngubane et al., 2022; Beasley et al., 2024; Plass et al., 2024). Prince et al. (2024) found that undergraduate research can increase research self-efficacy and students' confidence in using their technical knowledge. The present study builds on that discussion, as the participants linked undergraduate research to entrepreneurship readiness. Specifically, research helped them develop problem-solving, critical

thinking, and opportunity recognition skills and apply their theoretical knowledge in practice. All these competencies are also necessary in entrepreneurship and venture development (Ratten & Jones, 2021; Avrithi & Clagett, 2024).

Moreover, the participants' focus on the importance of practicality and value creation is also aligned with Lackéus' (2020) VaCP. In particular, rather than seeing entrepreneurship as just the establishment of a business entity, the participants realised the value of research that produces goods and services to address the needs of the industry and society. This finding supports the arguments of Crişan et al. (2024) that EE is more relevant for non-business students when integrated into discipline programs. Nevertheless, the findings suggest that the process of integration needs support from the side of the institutions in terms of curriculum alignment, mentorship, funding, and practical activities. Some of the benefits associated with the integration of undergraduate research and entrepreneurship included skills development, personal development, money-making, creation of jobs, and contributions to society. Hence, entrepreneurship was considered not only as one of the career choices but also as one of the solutions to unemployment and societal needs. Thus, it is evident that some students may be motivated not only economically but also socially.

The major barriers mentioned by the participants included academic burden, limited funds, inflexible curricula and lack of awareness of support available to students. Such barriers were also mentioned by the participants of studies investigating the implementation of EE in engineering and other STEM disciplines (Ndedi, 2013; Huang-Saad et al., 2018; Ngubane et al., 2022; Avrithi & Clagett, 2024). The fact that the participants had difficulties balancing their academic responsibilities and entrepreneurship shows that entrepreneurship programs may become unsustainable if provided mainly outside the curriculum. Therefore, it is suggested that entrepreneurial activities could be embedded in students' research, design and project activities.

Apart from that, some of the limitations mentioned by the participants were weak motivation, awareness and engagement of institutions in entrepreneurial activities. Even though certain structures such as Innobiz were mentioned by the participants, they needed constant mentorship, increased visibility during lectures and practical training related to certain sectors. It is evident from this finding that the mere existence of entrepreneurship support structures cannot guarantee students' active participation. The structure must be visible and easily accessible to students and associated with their academic experience. It should be noted that not all the participants aspired to establish a venture. One of the participants preferred to become a manager and analyst in an existing business organisation. This finding shows the significance of recognising various types of entrepreneurial identities. Therefore, entrepreneurship programs must be designed in a way to facilitate not only venture founding but also contribution through management, innovation, strategic decision-making and the growth of existing ventures.

The concerns about the intellectual property raised by one of the participants need to be treated carefully. This answer shows that the issue of uncertainty about the ownership and commercialisation of innovations created by students may influence their motivation to conduct research for entrepreneurship purposes.

Therefore, clear communication and induction of existing intellectual property policies may increase confidence in research-driven entrepreneurship. In general, it can be concluded that undergraduate research may serve as a good platform for the entrepreneurship competency development of engineering students. Nevertheless, its contribution depends on the degree of integration of research, curriculum activities and institutional entrepreneurship support. It is essential to note that based on the small sample size of the context-specific participants, the findings of the study can be seen as preliminary.

CONCLUSIONS

This study looked at the relationship between undergraduate research and entrepreneurship among students pursuing a diploma in civil engineering at a university in South Africa. According to the results, combining undergraduate research with EE can give students chances to hone their problem-solving, theory-application, creativity, and employability skills while also paving the road for entrepreneurial endeavours. Mentorship and access to institutional innovation centres were also noted by participants as crucial channels for converting research concepts into business potential. However, there are still significant obstacles to this integration, including hefty academic workloads, a lack of finance, inadequate entrepreneurial training, and differing levels of student motivation.

The findings can be useful for higher education institutions that want to improve entrepreneurship in STEM programs. Civil Engineering program and faculty curriculum leaders should consider incorporating relevant aspects of entrepreneurship (such as opportunity identification, business development, innovation and intellectual property) into engineering modules and research activities, instead of only relying on extracurricular activities. Mentorship, project opportunities and seed funding can be provided by business and public sector partners; however, entrepreneurship centres and institutional innovation hubs need to provide structured mentorship and clearer pathways to incubation, prototyping and finance. Such initiatives may enable engineering students to translate research-oriented ideas into useful and potentially profitable applications in a more accessible institutional environment.

The study also emphasises the importance of acknowledging that students may interact with entrepreneurship in a variety of ways, from starting new businesses to honing their entrepreneurial skills within already existing firms. Therefore, a flexible approach to EE might be preferable to a singular entrepreneurship pathway. However, the small purposive sample ($n = 8$), which was selected among students associated with Innobiz, should be taken into consideration when interpreting the results, as it restricts generalisability and raises the risk of self-selection bias.

To improve the robustness and transferability of the results, future research should overcome this limitation by enlisting larger samples from various civil engineering cohorts and institutions and, when practical, use suitable sampling techniques. The viewpoints of educators, academic administrators, mentors from entrepreneurship centres, and business partners should all be included in future research. A more thorough knowledge of the institutional elements impacting

engineering entrepreneurship would result from such a larger and more varied sample, which could also look at how these factors affect students' entrepreneurial development over time.

ACKNOWLEDGEMENT

This research was supported by the Durban University of Technology through a ZAR 30.000 grant from the Scholarship of Teaching and Learning (SoTL) project.

Overall AI Involvement Summary

The authors declare that no artificial intelligence (AI) tools were used in the preparation, writing, analysis, or revision of this manuscript.

REFERENCES

- Adu, I. N., Boakye, K.O., Suleman, A.-R., and Bingab, B.B.B. (2020). Exploring the factors that mediate the relationship between entrepreneurial education and entrepreneurial intentions among undergraduate students in Ghana. *Asia Pacific Journal of Innovation and Entrepreneurship*, 14(2), 215–228. <https://doi.org/10.1108/apjie-07-2019-0052>
- Andalibi, M. (2019). Early incorporation of entrepreneurship mindset in an engineering curriculum. *International Journal of Higher Education*, 8(4), 98–107. <https://doi.org/10.5430/ijhe.v8n4p98>
- Astiana, M., Malinda, M., Nurbasari, A., and Margaretha, M. (2022). Entrepreneurship education increases entrepreneurial intention among undergraduate students. *European Journal of Educational Research*, 11(2), pp. 995–1008. <https://doi.org/10.12973/eu-jer.11.2.995>
- Avrithi, K., and Clagett, D. (2024). A study on undergraduate engineering research. *2024 IEEE Frontiers in Education Conference (FIE)*, 1–6. <https://doi.org/10.1109/FIE61694.2024.10893467>
- Barba-Sánchez, V., and Atienza-Sahuquillo, C. (2018). Entrepreneurial intention among engineering students: The role of entrepreneurship education. *European Research on Management and Business Economics*, 24(1), 53–61. <https://doi.org/10.1016/j.iiedeen.2017.04.001>
- Beasley, H. K., Vue, Z., McReynolds, M. R., Neikirk, K., Garza-Lopez, E., Mungai, M., Marshall, A. G., Shao, B., Benjamin, J., Wanjalla, C. N., and Hinton, A. Jr. (2024). A review of undergraduate research programs aimed at underrepresented students. *STAR Protocols*, 5(2), article 102997. <https://doi.org/10.1016/j.xpro.2024.102997>
- Bethlehem, J. (2010). Selection bias in web surveys. *International Statistical Review*, 78(2), 161–188. <https://doi.org/10.1111/j.1751-5823.2010.00112.x>
- Bowman, N. A., and Holmes, J. M. (2018). Getting off to a good start? First-year undergraduate research experiences and student outcomes. *Higher Education*, 76(1), 17–33. <https://doi.org/10.1007/s10734-017-0191-4>
- Browning, J. W., and Bustard, J. (2024). A systematic literature review of entrepreneurial education in electrical, electronic, and computer engineering curricula. *IEEE Access*, 12, 7927–7941. <https://doi.org/10.1109/ACCESS.2024.3352162>
- Burkey, D. D., Bozorgmanesh, H., Srivastava, M., and Mendes, R. (2019). Entrepreneurial engineering education: A research experience for undergraduates focused on entrepreneurship and technical innovation. In *Proceedings of the 2019 ASEE Annual Conference and Exposition*. <https://peer.asee.org/32754>
- Crișan, E. L., Beleiu, I. N., Salanță, I. I., Bordean, O. N., and Bunduchi, R. (2024). Embedding entrepreneurship education in non-business courses: A systematic review and guidelines for practice. *Management Learning*, 55(4), 553–575. <https://doi.org/10.1177/13505076231169594>

- Etikan, I., Musa, S. A., and Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>
- Gambheer, R., and Acharya, U.S. (2024). Work-integrated learning in engineering education: Bridging theory and practice. In *2024 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE)*, 1–8. IEEE. <https://doi.org/10.1109/TALE62452.2024.10834371>
- Gilmartin, S. K., Thompson, M. E., Morton, E., Jin, Q., Chen, H. L., Colby, A., and Sheppard, S. D. (2019). Entrepreneurial intent of engineering and business undergraduate students. *Journal of Engineering Education*, 108(3), 316–336. <https://doi.org/10.1002/jee.20283>
- Haeger, H., Banks, J. E., Smith, C., and Armstrong-Land, M. (2020). What we know and what we need to know about undergraduate research. *Scholarship and Practice of Undergraduate Research*, 3(4), 62–69.
- Hasan, S. M., Khan, E. A., and Nabi, M. N. U. (2017). Entrepreneurial education at university level and entrepreneurship development. *Education + Training*, 59(7/8), 888–906. <https://doi.org/10.1108/ET-01-2016-0020>
- Healey, M., and Jenkins, A. (2009). *Developing Undergraduate Research and Inquiry*. York: Higher Education Academy.
- Huang-Saad, A. Y., Morton, C. S., and Libarkin, J. C. (2018). Entrepreneurship assessment in higher education: A research review for engineering education researchers. *Journal of Engineering Education*, 107(2), 263–290. <https://doi.org/10.1002/jee.20197>
- João, I. M., and Silva, J. M. (2020). Developing an entrepreneurial mindset among engineering students: Encouraging entrepreneurship into engineering education. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje*, 15(3), 138–147. <https://doi.org/10.1109/RITA.2020.3008105>
- Lackéus, M. (2020). Comparing the impact of three different experiential approaches to entrepreneurship in education. *International Journal of Entrepreneurial Behavior & Research*, 26(5), 937–971. <https://doi.org/10.1108/IJEBR-04-2018-0236>
- Law, K. M. Y., and Breznik, K. (2017). Impacts of innovativeness and attitude on entrepreneurial intention: Among engineering and non-engineering students. *International Journal of Technology and Design Education*, 27(4), 683–700. <https://doi.org/10.1007/s10798-016-9373-0>
- Linn, M. C., Palmer, E., Baranger, A., Gerard, E., and Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. *Science*, 347(6222), 1261757. <https://doi.org/10.1126/science.1261757>
- Little, C. (2020). Undergraduate research as a student engagement springboard: Exploring the longer-term reported benefits of participation in a research conference. *Educational Research*, 62(2), 229–245. <https://doi.org/10.1080/00131881.2020.1747360>
- Mathushan, P. (2020). Instilling entrepreneurial mind-set through entrepreneurship education: A systematic review of literature. *Sabaragamuwa University Journal*, 18(1), 43–54. <https://doi.org/10.4038/suslj.v18i1.7753>
- Moraes, G. H. S. M., Iizuka, E. S., and Pedro, M. (2018). Effects of entrepreneurial characteristics and university environment on entrepreneurial intention. *Revista de Administração Contemporânea*, 22, 226–248. <https://doi.org/10.1590/1982-7849rac2018170133>
- Ndedi, A. A. (2013). Challenges and perspectives facing the development of entrepreneurship education and training in South Africa. *World Journal of Entrepreneurship, Management and Sustainable Development*, 9(2/3), 126–132. <https://doi.org/10.1108/WJEMSD-01-2013-0009>
- Ngubane, Z., Hay, S., and Adedeji, J. (2022). Assessing the impact of undergraduate research on graduate attributes development: A case study of DUT Civil Engineering students. *African Journal of Inter/Multidisciplinary Studies*, 4(1), 28–42. <https://doi.org/10.51415/ajims.v4i1.996>
- Nielsen, S. L., and Gartner, W. B. (2017). Am I a student and/or entrepreneur? Multiple identities in student entrepreneurship. *Education + Training*, 59(2), 135–154. <https://doi.org/10.1108/ET-09-2014-0122>
- Nsahlai, V. K., Zogli, L. K. J., Lawa, E., and Dlamini, B. I. (2020). Factors influencing entrepreneurial intention: A case of students in a South African university. *Academy of Entrepreneurship Journal*, 26(1), 1–14.

- Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., and Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533–544. <https://doi.org/10.1007/s10488-013-0528-y>
- Park, E., Leonard, A., Delano, J. S., Tang, X., and Murphy, M.D. (2020). Rubric-based assessment of entrepreneurial minded learning in engineering education: A review. *International Journal of Engineering Education*, 36(6), 2015–2029.
- Plass, K. E., Krebs, J. K., Morford, J. L., Schaak, R. E., Stapleton, J. J., and van Duin, A.C. (2024). Nanomaterials research at a primarily undergraduate institution: Transforming nanorods, undergraduate research communities, and infrastructure. *ACS Nanoscience Au*, 4(4), 223–234. <https://doi.org/10.1021/acsnanoscienceau.4c00005>
- Prince, B., Jaiswal, A., and Joshi, V. (2024). Characterizing research self-efficacy among undergraduate engineering students. In *2024 IEEE Frontiers in Education Conference (FIE)*, 1–6. IEEE. <https://doi.org/10.1109/FIE61694.2024.10893005>
- Puni, A., Anlesinya, A., and Korsorku, P. D. A. (2018). Entrepreneurial education, self-efficacy and intentions in Sub-Saharan Africa. *African Journal of Economic and Management Studies*, 9(4), 492–511. <https://doi.org/10.1108/AJEMS-09-2017-0211>
- Ratten, V., and Jones, P. (2021). Entrepreneurship and management education: Exploring trends and gaps. *The International Journal of Management Education*, 19(1), 100431. <https://doi.org/10.1016/j.ijme.2020.100431>
- Ratten, V., and Usmanij, P. (2021). Entrepreneurship education: Time for a change in research direction? *The International Journal of Management Education*, 19(1), 100367. <https://doi.org/10.1016/j.ijme.2020.100367>
- Rodríguez Gutiérrez, P. I., Pastor Pérez, M. P., and Alonso Galicia, P. E. (2019). University entrepreneurship: How to trigger entrepreneurial intent of undergraduate students. *Journal of Science and Technology Policy Management*, 10(4), 927–950. <https://doi.org/10.1108/JSTPM-04-2018-0037>
- Seifan, M., Lal, N., and Berenjian, A. (2022). Effect of undergraduate research on students' learning and engagement. *International Journal of Mechanical Engineering Education*, 50(2), 326–348. <https://doi.org/10.1177/0306419021988962>
- Shekhar, P., and Huang-Saad, A. (2021). Examining engineering students' participation in entrepreneurship education programs: Implications for practice. *International Journal of STEM Education*, 8(1), 40. <https://doi.org/10.1186/s40594-021-00298-9>
- Stephens, A., Brenner, K., and Gentile, J. (2017) *Undergraduate Research Experiences for STEM Students: Successes, Challenges, and Opportunities*. Washington, DC: National Academies Press.
- Sun, H., Lo, C. T., Liang, B., and Wong, Y. L. B. (2017). The impact of entrepreneurial education on entrepreneurial intention of engineering students in Hong Kong. *Management Decision*, 55(7), 1371–1393. <https://doi.org/10.1108/MD-06-2016-0392>
- Vodă, A. I., and Florea, N. (2019). Impact of personality traits and entrepreneurship education on entrepreneurial intentions of business and engineering students. *Sustainability*, 11(4), 1192. <https://doi.org/10.3390/su11041192>
- Walkington, H. (2015) *Students as Researchers: Supporting Undergraduate Research in the Disciplines in Higher Education*. York: Higher Education Academy.
- Wathanakom, N., Khlaisang, J., and Songkram, N. (2020). The study of the causal relationship between innovativeness and entrepreneurial intention among undergraduate students. *Journal of Innovation and Entrepreneurship*, 9(1), 15. <https://doi.org/10.1186/s13731-020-00125-5>
- Woodcock, C. S. E., Shekhar, P., and Huang-Saad, A. (2019). Examining project-based entrepreneurship and engineering design course professional skills outcomes. *International Journal of Engineering Education*, 35(2), 631–644.
- Yan, H., Chen, Z., and Jiao, Y. (2021). Cultivation of innovation ability in practical teaching of mechanics under new engineering. In *2021 2nd Information Communication Technologies Conference (ICTC)*, 390–393. IEEE. <https://doi.org/10.1109/ICTC51749.2021.9441608>

AUTHORS' SHORT BIOGRAPHY



Jacob Adedayo Adedeji received the Doctor of Engineering degree from the Central University of Technology, Free State. He is a Lecturer in Transportation Engineering and Pavement Design at the Durban University of Technology, South Africa. His research interests include sustainable road materials, pavement design, recycled pavement technologies, road-user behaviour, and engineering and entrepreneurship education. He is also committed to advancing sustainable transportation and mentoring future engineering professionals.

E-mail: jacoba@dut.ac.za

ORCID iD: <https://orcid.org/0000-0002-3222-7846>



Zesizwe Sibiya (née Ngubane) is a Civil Engineering academic and researcher in the Department of Civil Engineering at the Durban University of Technology, South Africa. She received the BSc and MSc degrees in Geological Sciences/Hydrogeology from the University of KwaZulu-Natal and the Doctor of Engineering degree in Civil Engineering. She is professionally registered as a Professional Natural Scientist (Pr. Sci. Nat.) with SACNASP. Her research interests include hydrology, hydrogeology, water quality, catchment modelling, environmental risk assessment, artificial intelligence for environmental decision support, engineering education, innovation and entrepreneurship. E-mail: zesizwen@dut.ac.za

ORCID iD: <https://orcid.org/0000-0001-5379-2580>



Nontokozo Ngcobo is the Senior Centre Manager at innobiz DUT, the Centre for Entrepreneurship and Innovation at the Durban University of Technology, Durban, South Africa. She received the MBA degree from Anglia Ruskin University, United Kingdom, and the PhD degree from the Durban University of Technology in Entrepreneurship Education. She also holds Leadership Development Coach credentials and two board certifications from the Institute of Directors South Africa. Her research and professional interests include entrepreneurship education, entrepreneurship development, innovation, business development, leadership, programme development and youth enterprise support.

E-mail: nontokozon@dut.ac.za

ORCID iD: <https://orcid.org/0000-0002-2300-9177>



Shanley Hay received the MTech degree in civil engineering from the Durban University of Technology in 2013, the BTech degree in civil engineering (water) in 2009, and the National Diploma in civil engineering in 2005. An ECSA-registered Professional Civil Engineering Technologist, he has 23 years of industry and 15 years of academic experience. He is an external moderator, mentors engineering candidates, leads professional training, and serves as an ECSA Accreditation Team Member, Education Evaluator and Professional Registration Reviewer. Previously, he served as the Interim Head of Department, Deputy Head, Qualification Development Champion and Lecturer at the Department of Civil Engineering (Midlands)

at the DUT. His research interests include engineering education, undergraduate research, graduate attributes, entrepreneurship, innovation and trenchless technology for potable water pipeline rehabilitation and replacement.

E-mail: hayshanley@gmail.com

ORCID iD: <https://orcid.org/0000-0002-7602-7969>