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Business Engineering 4.0: The Transformation of a University Course in Response to Industry 4.0, Sustainable Development Goals, & Covid-19 in South Africa

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ABSTRACT

The rising waves of Industry 4.0, Sustainable Development Goals and COVID-19 have resulted in repercussions that have challenged the status quo. In preparation, Action Design Research (ADR) was used in Engineering Education as an adaptive mechanism. This research paper follows a 5-year development journey of a Business Engineering course at a South African university. The paper discusses the adaptations and refinements in response to the waves above and how they were integrated in the content, presentation and assessments of the course. Furthermore, this paper extracts generalizable findings for Engineering Education and reflects on the design of the next cycle of the course in anticipation of further waves.

KEYWORDS

experiential learning, action design research, Engineering Education 4.0, online-learning, responsive course design

1 RESEARCH OVERVIEW

1.1 Introduction to context

The year is 2017… The place is a school for Industrial Engineering at a well-known South African tertiary institute… The aim is to design a course that can equip students with the unique skill of navigating disruptive waves. In the 5-year period between 2017 to 2021, the disruptive waves of Industry 4.0, Sustainable Development Goals and Covid-19 event simultaneously eroded sandcastles that stood for decades and uncovered new pearls. Continually designing the content of a course shares similarities with wave surfing. The challenge is generating a meaningful experience by carefully selecting which wave to closely explore and land in a controlled manner. This appears to be

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one of the few ways to provide a holistic view in the 21st century to prepare students for industry. This paper discusses the findings and learnings pertaining to the continuous design of a Business Engineering using Action Design Research (ADR).

1.2 Background on Engineering Education

Perhaps one of the most important things to consider when designing education courses and content for engineers is understanding that "Engineers must learn how to merge the physical, life, and information sciences at the nano-, meso-, micro- and macroscales" [1]. Especially doing so within a paradigm of sustainability where the economy is a subset of society, and both are governed by the environment. For this specific reason, examining the impact of macro developments and reflecting them in a creative manner in the course content and presentation mode is essential.

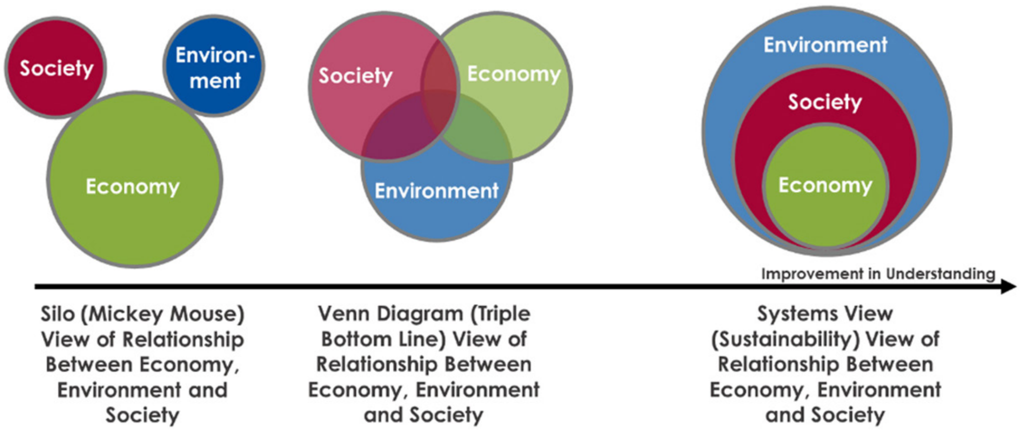

Fig. 1. Evolution of economy, environment and society relationship [2]

Growing industry needs, impactful technological trends, student engagement and creative learning environments require engineering educators to adapt and recognize the influence of these waves in order to adapt mechanisms for knowledge, skills and competency development. Yet, the pedagogical practice of engineering education, according to a competence approach, is argued to be scientifically based in order to prepare the future engineer [3].

1.3 Examining the impact on a Business Engineering course

Business Engineering is a sub-discipline of industrial engineering that aims to integrate business functions, processes, information systems and organization structures for quantifiable value in an enterprise [4]. It is an essential part of the industrial engineering curriculum at South African tertiary institutes. It also forms part of a broader strategy to align engineering education to the needs of the industry. The Business Engineering course, by nature, is multi-disciplinary and needs to provoke critical thinking and reflection [5]. Moreover, it needs to align with recent developments, trends and events to ensure that the content's relevant outputs are viable. Given this fact, the course needed to be interactive and experiential in nature to ensure knowledge is internalized. This would allow graduates to apply it in broader contexts. This paper uses Action Design Research (ADR) to contextualize, adapt and inspire the development, presentation and assessment of the Business Engineering course in response to yearly dynamic changes.

2 RESEARCH METHODOLOGY

2.1 Action Design Research (ADR)

For the purposes of this study, Action Design Research (ADR) was used to record the advancements made in the module. Action Research (AR) tries to establish the role of knowledge and as a discourse for theoretical insight [6]. More specifically, Action Design Research (ADR) offers itself as a method that addresses a problem encountered in various settings by designing and evaluating an artefact which is state-of-the-art [7]. Action design research proposes that artefacts are "shaped by the organizational context during development and use" [7]. The ADR methodology can be explained in 4 distinct stages, as encompassed in Figure 2.

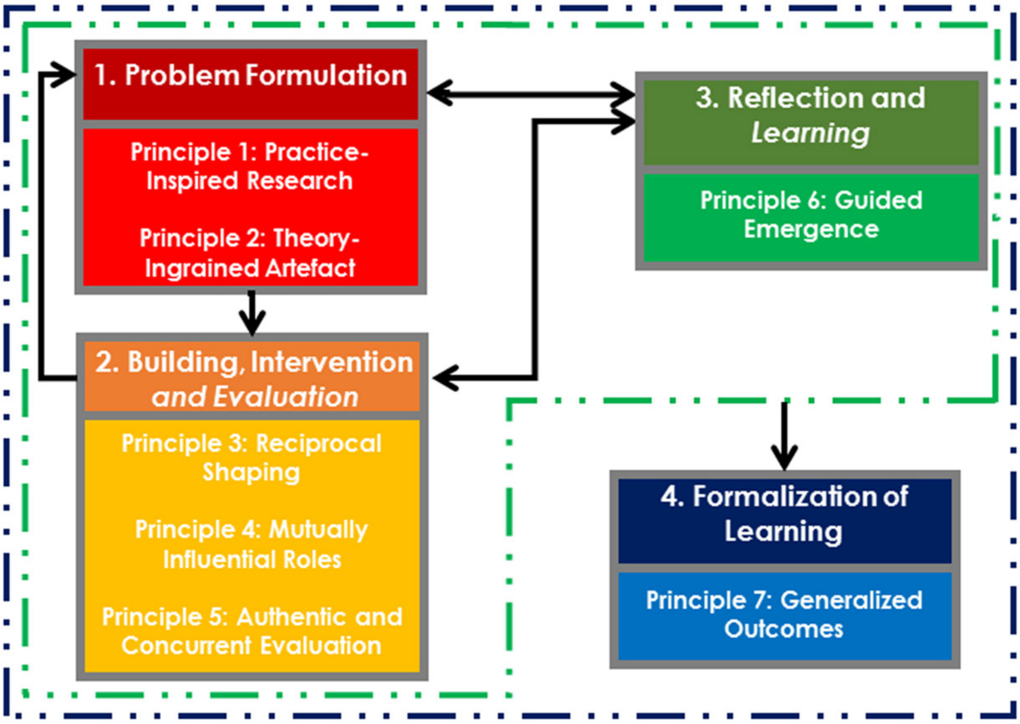

Fig. 2. ADR methodology used to formalize learning Business Engineering course [7]

Building on the premise of seeking design inspiration through ADR, research efforts have translated the methodology with an evolution contextualization model [8]. Each of these stages serves an independent purpose in the module. The first three stages of the ADR methodology allow some flexibility before formalization. Principle 1 "emphasizes viewing field problems (as opposed to theoretical puzzles) as knowledge-creation opportunities" [7]. Principle 5 means that "evaluation is not a separate stage of the research process that follows building" [7]. Principle 6 ensures a "sense of organic evolution" [7]. Thus, ADR "captures seemingly incongruent perspectives" [7]. Whereas the formalized learning constitutes the new year by refining the course according to its emergent needs, yet, this is challenging "because of the highly situated nature of ADR outcomes" [7]. This research will analyze the business ideas created by each student amongst each architect type, year and Industry 4.0 technology discussed in section 4. These findings are also visualized and interpreted over a five year period. Section 3 discusses literature content specific to each wave the course experienced.

3 APPLIED LITERATURE REVIEW

In order to provide a comprehensive overview of the waves that guided the actions and design efforts of the course: a macro, meso and micro review of the relevant literature is conducted. This review details aspects that are responsible for these waves and their impact on the course.

3.1 Macro review

Industry 4.0. The Fourth Industrial Revolution (commonly referred to as Industry 4.0) was driven by significant technological advancements that produce disruptive changes at national, industry and company levels [9]. Maisiri, et al. [10] believe that the Fourth Industrial revolution will reinvent core competencies and skills for the workforce of the future. These advantages initiated a race to understand and implement these technologies at a company and national level. These efforts welcome new challenges in skill requirements due to the increased complexity of all tasks involved. Not only are skill complexity and task frequency shuffled by Industry 4.0 technologies, but it led to a transformation of jobs that will create future opportunities for productive employment [10]. For this transformation to take full form, the development of technical and soft skills needs to be nurtured by academic institutions.

South Africa, like many developing countries, is confronted with high unemployment rates, scarce skill shortages and higher economic strain than before, directly affecting various industries [9]. For developing countries, Industry 4.0 technologies may aid in remedying and uplifting societal well-being. Acclimatizing and incorporating it into societies requires a re-evaluation of its integration factors in order to accommodate Industry 4.0 skill requirements and economic growth [10]. With Industry 4.0 technologies being implemented in organizations, new skills, knowledge and capabilities are prescribed. Maisiri and Dyk [11] argue that beyond the Fourth Industrial Revolution, graduates will be reliant on proactive learning, creativity and innovation. This course inspires future engineers to design realistic yet innovative business ideas that may alleviate the socio-economic factors that still plague the country. The benefits of Industry 4.0 have reaped new applications for diversified and unique value offerings. A promising adoption has been witnessed in a business setting. This transformation is often referred to as Business 4.0 (one of many Industry 4.0 neologisms). The use of Industry 4.0 for business model innovation produces a novel business case with personalized, predictive and intuitive value propositions for customers [12]. These advantages can simply be directed towards a holistic vision for a more synergetic effect and alignment of core principles within an organization or business.

Sustainable Development Goals. Another significant macro development was the introduction of the Sustainable Development Goals (SDG) in 2015 at the UN to replace the Millennium Development Goals (MDG) due to various shortcomings of the MDGs [13]. The main advantage of the SDGs is that they are broader and could potentially lead to a bigger transformation [13]. Perhaps what is more important is the broad-reaching 3-year consultation process that led to the SDGs, which can be arranged "into three pillars: social, environmental, and economic" [14]. Thus, it reflected aspirations of various individuals, communities, enterprises, and governments to be more sustainable moving forward. It is important to note that achieving the goals requires "transformation of societies that is faster and far more substantive than in the past—the rate of change that a Business-As-Usual (BAU) approach cannot deliver" [14]. Universitities have a crucial role in promoting the SDGs [15], and this course makes efforts to do so.

Fig. 3. Sustainable Development Goals arranged into 3 pillars [14]

Covid-19. December 2019 unceremoniously welcomed the novel Coronavirus Disease (COVID-19). The nature of this disease soon qualified itself as an International Concern in January 2020, and a pandemic only two months later. The ramifications of this disease are unbounded. COVID-19 has been unbiased with regard to the country or sector it negatively affects. Engineering education is no exception to this, demanding tertiary institutions to make drastic changes to the mode of contact and assessment. Testifying to this, academic scholars have shared their experiences from countries such as India and USA [16]. In a German institute, it was found that a flipped classroom approach and use of digital tools would aid in effective teaching and learning amid the pandemic [17]. South Africa is not exempt from the demands imposed on teaching and learning. For tertiary institutions, it became crucial that students are safe, able to graduate and enter a very different work environment (that many were now unsure of and unprepared for) and actively contribute to the economy.

3.2 Meso review

Education 4.0. The combination of pedagogy, teaching principles and models, information sources, learning methods, student and lecturer roles influence the conceptualization of Education 4.0 [18]. The term Education 4.0 "is a response to the needs of IR4.0 where human and technology are aligned to enable new possibilities" [19]. Education 4.0 embraces a student-centred approach with shared cyber and physical spaces used to train soft and hard competencies [18]. It is important to note that Education 4.0 is not just a passing trend. It changes the "economic utilization of information in a remarkable way" [20]. This, in turn, changes the nature and method of information presented at the classroom level.

Sustainable development indicators & target areas. In order to make the SDGs more measurable, each SDG was linked to indicators and targets. This meant the SDGs represented a general state that was to be achieved (the why), whilst the indicators attempted to link actions to goals by creating alignment to reach the required result (the how). The 17 SDGs are linked to "169 associated targets and 232 indicators" [14]. Yet, "having one relevant indicator does not mean the target is covered—let alone the goal" [21]. Moreover, it is very important to remember that "targets apply to all countries, not just developing countries, and that they require reporting at the UN level" [21]. Although some developing countries have a longer way to go in some areas, they actually might be significantly ahead in other areas due to historical or cultural factors.

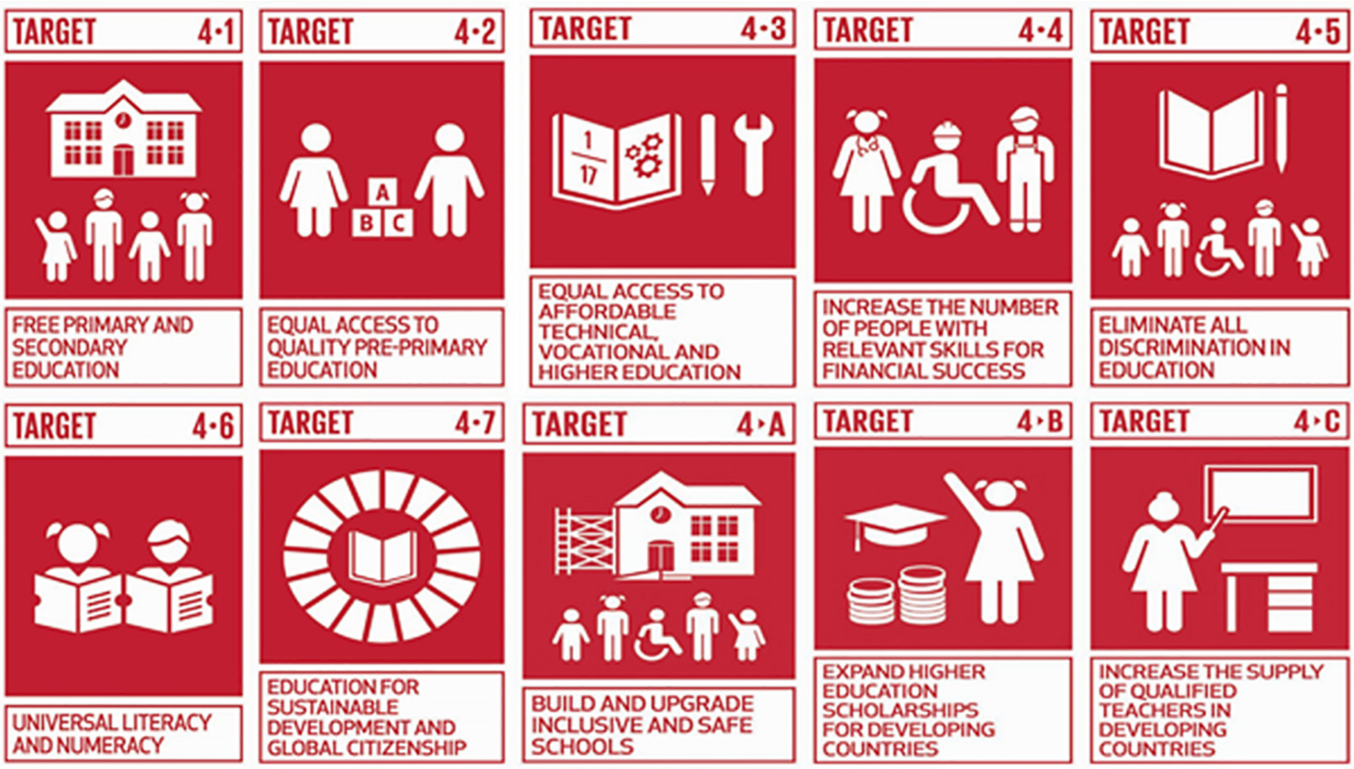

Fig. 4. SDG 4 (education) target areas [17]

Blended learning. Among the assortment of teaching methods that have been designed over a considerable time period, Blended learning has become a most noteworthy means to achieving effective learning. While definitions vary, the consolidated version by Cronje [22] deems this as a mix of theories, methods and technologies to optimize learning. In most forms of applications, this involves the use of learning systems to combine online and face-to-face instruction. Some of the fundamental challenges associated with blended learning is self-regulation, technology literacy and competency, student isolation, technological sufficiency and technological complexity [23]. It is argued that blended learning is the best-instructional mode for the engineering discipline [24].

However, for tertiary institutions, the effective adoption of blended learning becomes time and resource intensive [25]. This may well be the necessary investment for the future of graduates that can best prepare them for industry. Blended learning does more than just facilitate learning in an online environment, it enhances student confidence in their understanding, creates opportunities for more effective feedback and improves communication between the student and lecturer [26]. It stands to reason that COVID-19 has made Blended learning a more feasible and appropriate means of facilitating learning. In an evaluation on these effects, it was found that students became more engaged in online learning and more self-aware of their future career [27].

3.3 Micro review

Engineering Education 4.0. Engineering Education 4.0 (EE 4.0) integrates all engineering disciplines that generate engineers for Industry 4.0 [28]. Our new online learning environment prescribed by this pandemic online learning has also necessitated ethical guidelines for EE 4.0. For the lecturer, this means serving as a mentor that facilitates the engagement, creation and distribution of knowledge. The future of engineering education is undoubtedly shifting towards EE 4.0. For this to realize, efforts have been made to better understand how curricula, teaching and learning methods and assessments should change [29, 30].

In an uncertain job market that will be more reliant on skills defined by Industry 4.0, a sound means of preparing them is through EE 4.0 [29]. The exact composition of curricula for EE 4.0 is yet to be determined. Jeganathan, et al. [28] ask that engineering graduates are made vigilant of the types of skills and nature of Industry 4.0 technologies.

Sustainable Development Ships. In the well-known 1991 paper on defining entrepreneurship, a comprehensive overview is given on the different schools of thought surrounding what entrepreneurship really means. The paper notes how each view "provides insights about the many facets of entrepreneurial behavior" [31]. It is concluded that entrepreneurship is a reiterative process of personal evaluation, planning, acting, and reassessing which encourages people to take responsibility for creation and innovation. This process involves creating the idea, assessing one's personal abilities, and taking actions now and in the future. It assumes that entrepreneurs have the responsibility for the venture or share some of the risks and rewards of it [31].

Undiluted, entrepreneurship excludes low-risk, non-transformative venture whilst being highly connected to them. Yet, modern usage of the word covers self-started and small business ventures. The past 30 years have seen a rise in archetypes of entrepreneurship. Some are used colloquially whilst others have found rooting in academic theory that recognized their deviation from the standard entrepreneurial model either by altering the type of opportunity, the benefactor of the value created from the venture or nature of the innovation involved.

Notably, some of these architypes are an adaptation of the term "entrepreneurship" preceded by a short reference to macro-systems. Yet, this must be part of a broader approach to resolve the problem of "social and economic priorities being taught at the expense of ecological consideration" [4]. Ramirez-Mendoza explains that for Engineering Education "universities must align the educational strategies and models to SDG objectives that turn themselves into challenges for the entire planet and the subsistence of the human being on earth" [32]. Prominent archetypes and their definitions are summarized in Table 1 below:

Table 1. Prominent initiative archetypes

Archetype	
Entrepreneurship	Entrepreneur is derived from economic preneur (French for *taker*; presumably linked to a taker of risks or interesting opportunities).
Technopreneurship	Technopreneur is derived from technology entrepreneur. Technopreneurship is "involved in delivering an innovative hi-tech product or makes use of hi-tech in an innovative way to deliver its product to the consumer, or both. Technopreneurship is not a product but a process of synthesis in engineering the future of a person, an organization, a nation and the world" [33].
Intrapreneurship	Intrapreneur is derived from internal entrepreneur. Intrapreneurship is "the practice of developing a new venture within an existing organization, to exploit a new opportunity and create economic value. It is also known as corporate entrepreneurship and venturing" [34].
Sociopreneurship	Sociopreneur is derived from social entrepreneur. Sociopreneurship is "a mission-driven individual who uses a set of entrepreneurial behaviors to deliver a social value to the less privileged, all through an entrepreneurially oriented entity that is financially independent, self-sufficient, or sustainable" [35].
Ecopreneurship	Ecopreneur or Enviropreneur is derived from ecological or environmental entrepreneur. Ecopreneurship or Enviropraneurship "is an entrepreneurial orientation that addresses environmental problems and accommodates societal needs while simultaneously meeting the economic objective of organizations" [36].

Gamified learning. Gamification concerns itself with the innovative use of gamified elements in a non-game system to best achieve goals, change behavior and increase intrinsic and extrinsic motivation [37]. Within education, gamification has proven to aid in improving knowledge retention, problem-solving, collaboration and communication [38]. In certain instances, the intrinsic and extrinsic motivation factors within a gamified environment can ignite competitive behavior. This responsive behavior can be used to increase motivation and promote iterative thinking. This is most certainly the case in this Business Engineering course. Students are placed in a competition that incentivized by grades demarcated to overall performance and end ranking per category. Beyond the conceptual nature of the initiative students design in the course, each idea boards one of the 4 ships. Students pitch their ideas to a panel of expert judges from industry and academic. In this way, they provide critical feedback throughout the competition. Students must then battle against each other in knock-out stages of a competition.

4 BUSINESS ENGINEERING COURSE DESIGN

The Business Engineering course was designed for presentation during a full academic year, with contact sessions in bi-monthly block lecture days. This approach proved largely useful given some of the interdisciplinary connections requiring continuous exposure to Business Engineering concepts in order to develop. As Annan-Diab notes, "Professionals must be able to employ concepts from a variety of areas (including ethical theory, human rights, climate change, biodiversity and stakeholder management)" [39]. During classes, students engage with the content presented in the form of slides, interactive activities and videos. Yet, before each lecture, students had to read academic publications, case studies or extracts in advance. This allowed for a discussion-based approach to be followed in class. Much of these discussions concern the competitive advantage, strategic vision and performance of existing businesses and their interface with the engineering discipline.

To add a layer of depth, highly knowledgeable and experienced practitioners and academics are called on to share their perspectives, ideas and visions for the future. This opportunity gave the lecturer the role of a mediator, promoting this knowledge exchange while enabling introspective thinking and critical analysis that generate meaningful ideas and value for the future. Varied forms of assessment feedback were provided during the student's journey. An iterative understanding and reflection of the course content was owed to peer group reviews, guest speaker discussions, lecturer mentoring and critical feedback on class activities, assignments and formal assignments. However, the central assessment of the module constitutes the ideation, pitching and design of an innovative business concept in order to remedy challenges. The key difference in approach was that this design competition was the collaborative nature. A visual summary of the process is showcased below in Figure 5:

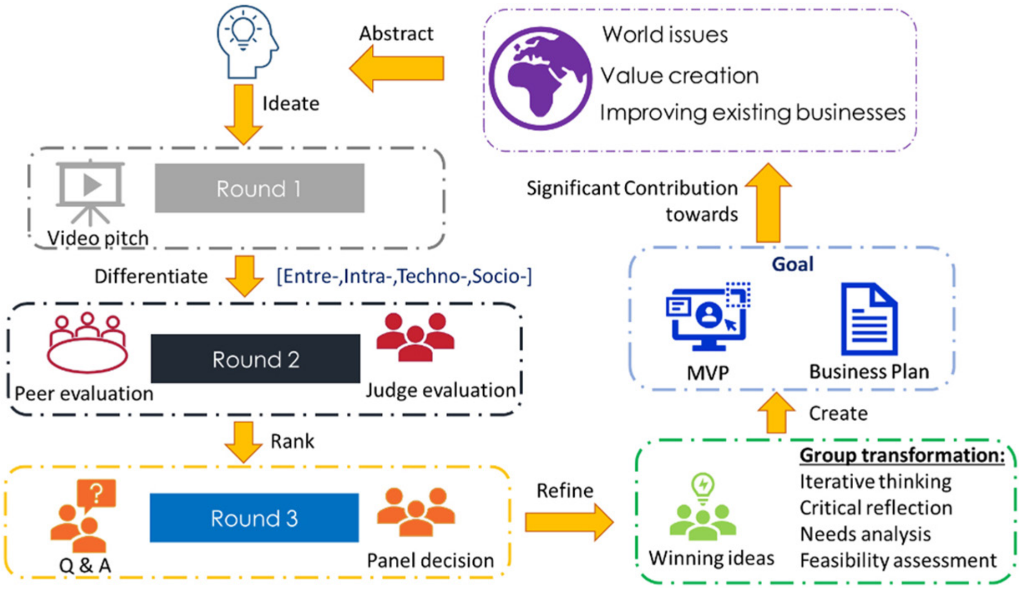

Fig. 5. Business Engineering collaborative competition process

After an initial pitching event where the most promising ideas under each category are selected, the top students must recruit their peers to join their team and develop the ideas into a workable business concept using the collective innovation and competencies available in the group. Expert judges from industry and academia provided critical feedback at each filtration stage to recommend potential synergies and partnerships. The team must then compile a Business Engineering Plan for examination. Moreover, groups are expected to demonstrate a Minimal Viable Product (MVP) as means of showcasing the core functions of their initiative. This journey allows them to reflect on engineering theory and the practical aspects it may concern. The primal goal of this approach was to mimic the skills and knowledge that will need to be applied in industry in a safe learning environment. It reinforced the confidence of students in their ability to make decisions, problem-solve, interpret and report on their ideas. More holistically, the end purpose is to surpass quality assurance obligations, but rather aid in establishing employability and instilling higher-order thinking.

4.1 Continuous navigation

Pre-wave navigation: Business Engineering initial design. The first big realization came during the inception of the course. The lecturer noted that Business Engineering knowledge had greater implementability when taught practically. In response, the focus shifted to establishing student's understanding of applications Business Engineering in the 21st century. The activities and projects orientated themselves around creating economically sound business models using the appropriate initiative type (entre, socio, techno, intra). Moreover, the course had to have a built-in 'radar' for waves.

1st wave navigation: Responding to Industry 4.0 & Business 4.0. The first wave that required navigation was the Fourth Industrial Revolution. It was agreed that tertiary institutions are obligated to provide knowledge and skills that are industry responsive, thereby calling on continuous modifications to the content, presentation, and abstraction from the modern world. Therefore, the inclusion of Industry 4.0 technologies in curriculum development is simply the next evolutionary step in preparing well-prepared and knowledgeable engineering graduates. After all, for the industrial engineer, industry relevance is their calling. Yet, given the course focused on the business impact of Industry 4.0, the focus shifted to Business 4.0 over time.

2nd wave navigation: Responding to Sustainable Development Goals. The second wave that was required during the same timeframe was the rise of the Sustainable Development Goals. The reason the SDGs were important was the fact that it did not make sense to design initiatives, businesses and enterprises with outdated indicators and goals when a more sustainable alternative exists. Covering the SDGs ensured that a fair amount of thought was given to the global impact of their initiative if and when scaled. In fact, most of the course assessment rubrics allocated marks for ethical, social and environmental awareness linked to the SDGs.

3rd wave navigation: Responding to Covid 19. Given two years of the course were affected by Covid 19, it was interesting to see the slow shift in modality towards a completely remote course. Interestingly, this trend started in 2019 for this course due to the importance of e-learning, which incidentally gave it an advantage when compared to other courses.

4.2 Continuous examination

One of the mechanisms employed that resulted in some noteworthy visual representations of the journey was the analysis and examination of 132 pitched initiatives during the 5-year period from 2017 to 2021. This time period helped identify some interesting trends and their connection with the impacting waves.

Pre-wave examination: Initiative diversity per year. The first meaningful visual representation of the initiative data is a showcase of the initiative diversity per year.

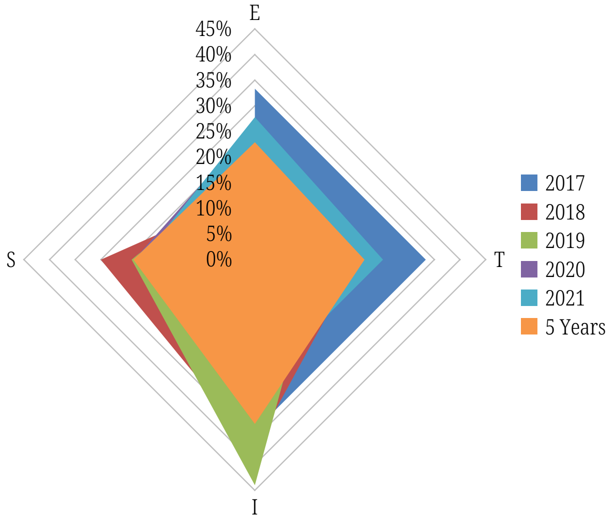

Fig. 6. Initiative diversity per year radar chart

Notably, although the initiative split between Entre, Socio, Techno and Intra reached an equilibrium by 2020, a shift towards what was 'new' and exciting can be seen in the early years of the course. A spike in sociopreneurial initiatives in 2018 and intrapreneurial in 2019 can be seen. When reflecting on these five years, the intrapreneurial initiative type presents itself as the most popular. The advantages of existing capital, resources and partners for such initiatives may explain this preference. The least dominant initiative type (Techno) over this period questions the ease and success of implementing business ideas with value propositions based on highly advanced technologies.

1st wave examination: Initiatives technology & Industry 4.0. In an interesting visual, the primary technologies utilized as the basis of the unique value offering of the business concept were mapped.

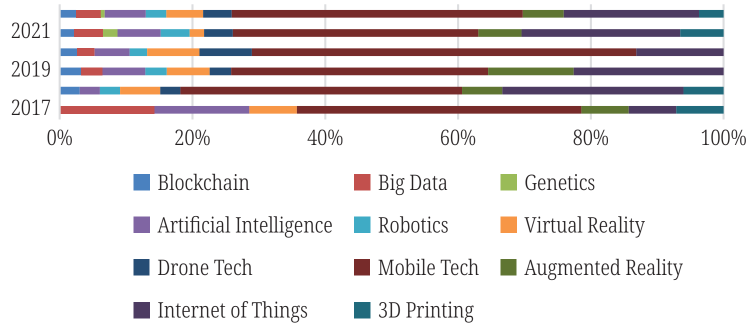

Fig. 7. Initiative technology utilization per year bar chart

Notably, mobile technology (in the broadest sense) remained a backbone in many value offerings with some spikes in certain technologies (AI and Big Data in 2017, Augmented Reality in 2019, Genetics in 2021), which can be seen as linked to interest in developments and news surrounding these technologies in their respective years. In addition to the general interest in the technologies prescribed in the figures above, there was a clear preference between certain technologies and initiative types. The use of robotics and genetics proved to be most unpopular during the 5-year period.

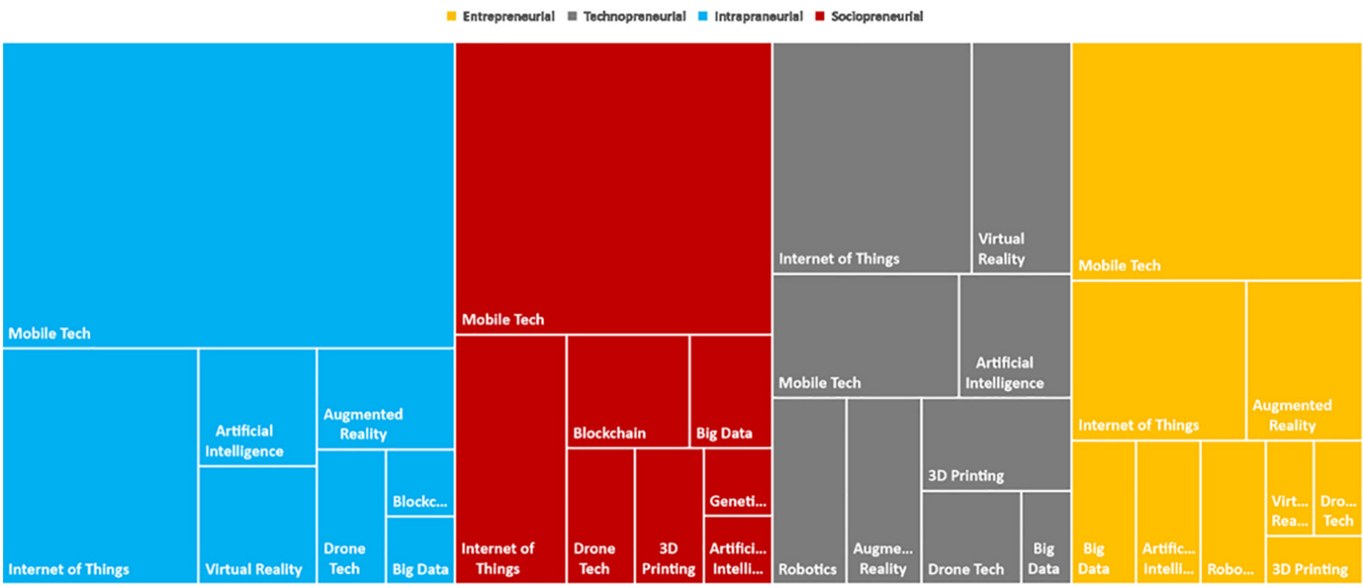

Fig. 8. Initiative technology utilization per initiative Treemap

It is worth mentioning that the most popular form of technology does not imply the most successful. The Treemap and table represent the roots of each idea proposed over the five years. For most sociopreneurial business initiatives, mobile technology platforms proved to be the most preferred form of deployment.

2nd wave examination: Initiatives scalability & SDGs. Revisiting the Sustainable Development Goals discussed in paper, the best-suited goals (SDG 9 Industry innovation and infrastructure, and SDG 3 Good health and well-being) voice a common purpose to uplift society and promote sustainable development. This can also allude to the most pressing challenges faced in South Africa, challenges that the students want to solve most urgently. While this was not an assessment criterion for these business initiatives, it most certainly demonstrates the general appeal and efforts these ideas strive to create: a more sustainable and beneficial society, economy and environment for all. The allocation of each SDG per idea was limited to a maximum for three ideas on average. The allocation towards a specific goal was strictly dictated by its core principle and the core value proposition of the business initiative.

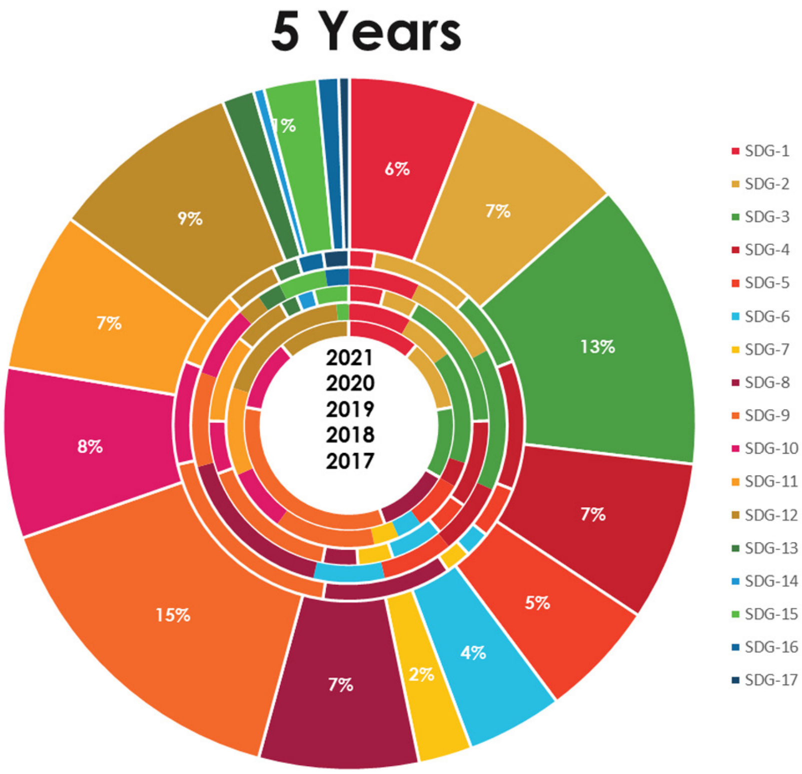

Fig. 9. Initiative *Scalability Impact* per year *Donut Chart*

Despite the attempt to address all of the SDGs, some of the goals (SDG 14 Life below water, SDG 16 peace, justice and strong institutions, and SDG 17 Partnerships for the goals) were not of much interest. These can be related to a lack in aquatic life awareness, the well esteemed justice system in South Africa and a secondary focus on the SDGs for the assessment.

3rd wave examination: Initiatives & impacted industries. Figure 10 represents the industry representation using ISIC codes. Similar to the screening method applied to the Sustainable Development Goals, the scope and customer segment from each business idea was used to allocate a maximum of 4 industries per idea.

If we were to image the ocean waves, the area chart signifies the strongest force at play. Each idea represents a wave that is condensed in some industries (**Q** Human health and social work activities, **R** Arts, entertainment and recreation, **S** other service activities and **T** Activities for households). These industries may also hold job opportunities for the future workforce in the developing countries such as South Africa. One can also base some of the results on the future of certain industries. Considering that these visuals represent the ideas that engineering graduates have for the future, it also offers insight into the prospects for future trends in the industries identified. Industrial engineers are instinctively sensitive to industry and its needs, challenging the status quo and integrating solutions between people, processes and technologies. Moreover, the limited focus on certain industries can also help identify industries that could be in need of more consideration or with barriers that could unlock unsuspecting potential.

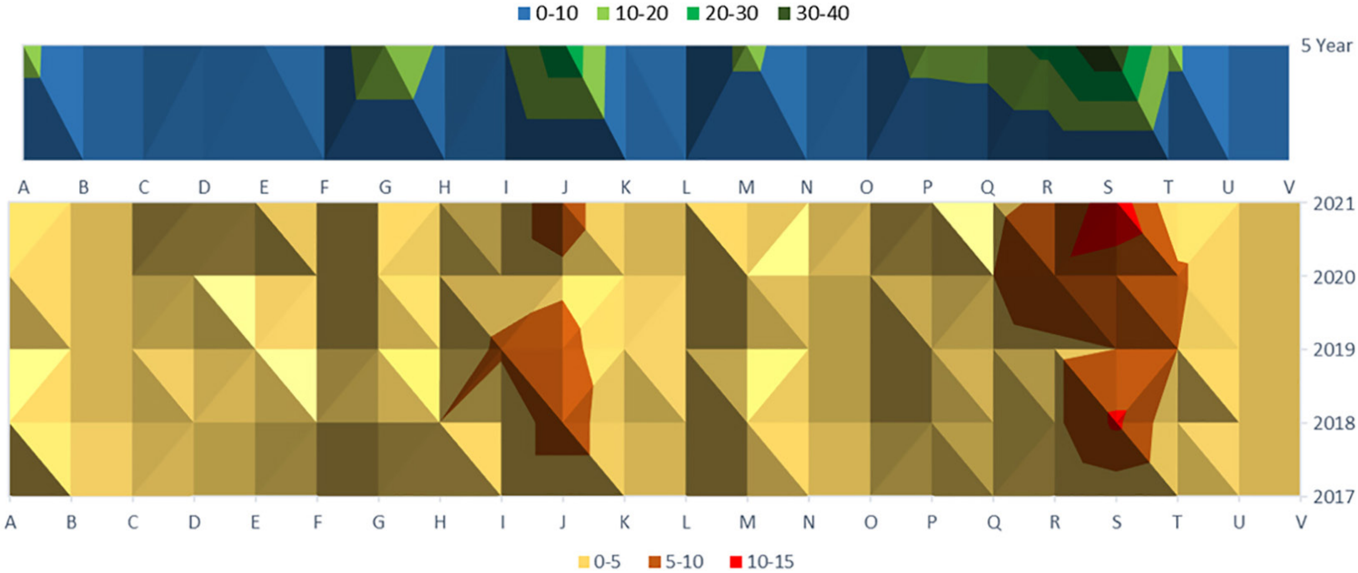

Fig. 10. Initiative *Impacted Industries Per Year Area Chart*

5 RESEARCH CONCLUDING REMARKS

5.1 Conclusions

Since entrepreneurship education has not received much focus in engineering pedagogy [43], there exists a need to inspire future engineers to hone and develop these skills in a careful and calculated manner. We believe that this course strives to do so. The influx of communication and news on COVID impacted the research and focus. During the early stages of the course, many of the ideas were inspired by trends students became familiar with. Although these interests fluctuated across the 5-year period, some technologies consistently prevailed and proved of value for a business case (Mobile Technology & Artificial Intelligence). Future work could explore the association between trends and "spikes of interest" in the engineering profession, and more specifically, for students. As educators, we need to remain mindful of these new developments and their influence on the ideas and perspectives students will adopt.

Another important lesson from this study was that generational needs and ways of thinking cannot be ignored. The way a platform influences learning can also impact student response and level of engagement. For the students, merely knowing about technology is not sufficient. The downside to generations is that learning and social environments can leave them unprepared and disconnected from practical considerations. For this reason, Engineering Education must also show students how to evaluate the ethical and technological aspects of their designs, ensuring that they are most appropriate and needed. Moreover, the environmental impact of engineering decisions must become common knowledge for future engineering graduates.

5.2 Adaptions for the future

For the future of education, online learning presents itself as an effective means to combat adversity. For this reason, academic scholars and practitioners have become fixated on creating a curriculum that supports and recognizes this dynamic environment, so much so that best practices are proposed. One careful consideration a lecturer must make is to understand and factor in student emotions in their teaching methods. Reason being, this may increase student stress levels, college retention, enrollment and academic emotions [40]. More interestingly, uncertainty has become a new norm from this pandemic, so a valuable contribution to any course are certainty and clear communication.

Despite the prospects of I5.0 still being debated [41], the continuous evolution of Engineering Education lends itself to what could soon be formalized as Engineering Education 5.0 (EE5.0). Finding inspiration from the Sustainable Development Goals, Lantada [41] postulates that this upcoming education paradigm envisages a more caring and sustainable future that follows a continuous evolution approach. Building on the principles of EE4.0, this new paradigm may integrate and establish synergy between economy, society and the environment. Within the academic sphere, the need to redesign curricula according to Industry 4.0 has indeed been acknowledged. Education 4.0 will only grow in relevance and interest in all parts of the world. This is subject to continued growth, especially with the growing interest in STEM and its challenges for Education in Engineering [41]. The need to link technologies with scientific ideas and industry developments is essential for future engineers [42]. According to Rutto et al. [42], programs should provide for society and industry, stressing the significance of what this course achieves. In agreement with this approach, Holzmann et al. [43] argue that entrepreneurship education is not given much attention within the field of engineering pedagogy. Therefore, efforts should be made to include this in engineering education.

6 ACKNOWLEDGEMENTS

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