Entrepreneurship education to stimulate entrepreneurial mindset in chemistry students

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A B S T R A C T

Chemistry is a field of study that teaches students critical skills in producing day-to-day products ranging from detergents, cosmetics, energy components and supplies for treating water. The majority of chemistry students seek formal employment after completing their studies, which helps to explain the increased incidence of unemployed South African graduates. This occurrence is more apparent in the Eastern Cape where there are very few chemistry industries with such employment opportunities. However, having an entrepreneurial mindset can lead to students venturing into business during or after their studies. Student businesses not only benefit the student but the community with accessible personalized solutions to their problems, institutions with reputation, creating a circular economy and possibly employment of others. Hence, this study aims to evaluate whether the offered entrepreneurship education to chemistry students stimulates an entrepreneurial mindset. The paper employed the qualitative narrative literature review methodology and the connectivism learning theory to achieve the set aim. Explored themes in realizing the aim are graduate attributes, science-based entrepreneurship education and entrepreneurial mindset. The key findings are that science-based entrepreneurship education lacks the embedment of fundamental chemistry that creates familiarity with the concept and subsequent relatability with the course content. The connectivism learning theory supports the link between familiarity and new learning opportunities whereby, in this case, an entrepreneurial mindset can be stimulated. The study proposes that entrepreneurship education for chemistry students must include chemistry-related case studies and a participatory practical approach as a co-curricula. The co-curricula aspect will involve opportunities to start a real business on campus during the semester in which the course is offered.

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Introduction

In a changing environment, the traditional academic disciplines are blurring. Several graduates are agile, adaptable, and equipped with a diverse set of skills that transcend conventional curricular confines. Thus, Higher education institutions (HEI) have the role of being flexible, accommodative and abreast with developments that are for the betterment of mankind. HEIs are expected to contribute to human capital and economic development in the form of generating knowledge that improves analysis of societal problems, creating accessible informed solutions and producing a competent labor force who are conscious of social and environmental justice (Sebola, 2022; Pitan and Muller, 2023). Most HEI students are youth who seek skills and attributes necessary to thrive in the real world by the time they graduate, in addition to formal education. The large number of unemployed graduates partially credited with university curriculum that is not equivalent to the abilities needed in the skills required in the volatile labor market (Mncayi, 2016; Ntale, 2022; Pitan & Muller, 2023).

The labor market is disrupted by changes in technology advancement, health emergencies and new methods as demanded by changes in the environment and globalization at large (Tomlinson et al., 2022; Pitan & Muller, 2023). The implementation of the changes can be urgent and does not afford the time required to reskill the labor force. For instance, the COVID-19 outbreak accelerated using
technology (Fourth Industrial Revolution). The workforce had to learn new methods of communication and operations in order to abide by social distancing required to curb the spread of COVID-19 (Caselli et al., 2022). On the other hand, scientists and health professionals were under pressure to discover the causes and properties of the virus in order to simulate the genetic strand for formulating the vaccine. On the other hand, the pandemic created new business opportunities such as chemical and biological products, hygienic products, screening equipment and biological waste handling. The consequent concern is whether our science graduates had the necessary skills and attributes to capitalize on these opportunities.

The curriculum offered in HEIs mainly focused on technicalities with sparing reference to developing soft skills and attributes. A chemistry student will have solid foundation knowledge of chemistry principles. However, the application of chemistry knowledge in the real world or navigating career development in the labor market is difficult to assess. The HEIs do not assess the readiness of graduates in terms of their attributes and soft skills. The essential graduate attributes include teamwork, communication, problemsolving, and soft skills (e.g. emotional intelligence, conflict resolution), multidisciplinary knowledge, promotion of entrepreneurship, career development skills and (Mohee & Putty-Rogbeer, 2020; Wong et al., 2021). Therefore, HEIs have a responsibility to create a conducive ecosystem in and outside the classroom that nurtures the development of the attributes. The HEIs must strive to produce graduates that possess the attributes for adapting to the unpredictable and ever-changing labor market (Orais on et al., 2019).

Entrepreneurship education as described by Ncanywa teaches attributes such as inventiveness and imagination, taking risks, strategic, selection-making, opportunism and collaborator in the company (Ncanywa, 2019). Entrepreneurship instruction is normally offered in certain programs such as business and accounting, mostly as a requirement to meet credit requirements for the program or as an extra-mural activity. In any case, entrepreneurship education is rarely offered in a participatory practical approach whereby students are exposed to real-life businesses (Ncanywa & Dyantyi, 2022). In relation to chemistry students, education in entrepreneurship offered tends to exist inclined toward business theory less than being a part of the R&D, scientific, and technology sectors (Blankesteijn et al., 2021). This may be attributed to the teacher having an entrepreneurship background and limited scientific knowledge. The idea of providing entrepreneurial education is gaining traction for all programs. However, challenges ranging from the practice of teaching entrepreneurship, contents of the educational program, science-based entrepreneurship education, balance between theory and practice and definitions and assessment of entrepreneurial mindsets (Linton and Xu, 2020; Miranda et al., 2020; Blankesteijn et al., 2021).

The education outcome of entrepreneurship education is to stimulate an entrepreneurial mindset but how can it be measured? The constellation of motivations, abilities, and mental processes that set entrepreneurs apart from non-entrepreneurs and facilitate their success is known as the entrepreneurial mentality (Davis et al., 2016). Other researchers argue that entrepreneurial mindset is a non-binary complex phrase characterized by tenacity, management of uncertainty, and adaptability (Fayolle & Gailly, 2015; Miranda et al., 2020; Tittel & Terzidis, 2020). The unclear definition of an entrepreneurial mindset shows the complexity of the concept and subsequently measurement. Hence, this study's objective is to further investigate if entrepreneurial mindset drives towards, the influence of entrepreneurship education on the mindset furthermore, ideally, work toward developing a practical technique for evaluating the learning objective.

**Theoretical framework and background**

This study aims to establish whether entrepreneurship education stimulates entrepreneurial mindset, with a particular focus on chemistry students. The spirit of entrepreneurship is viewed as a lesson learned during entrepreneurship training. The link between an entrepreneurial attitude and an education in entrepreneurship is explored through the lens of connectivism learning theory. The connectivism learning theory teaches students to combine theories, and general information and collaborate with people to create new learning opportunities (Kop & Hill, 2008). The learning process starts with the individual who makes connections with nodes (groups, learning networks, ideas and information resources) and the disciplinary context they find themselves in (Lyn & Fond, 2015; Rammund-Mansingsh & Reddy, 2021). The connectivism learning theory requires a student to contextualize theory into a skillset while considering the challenges and opportunities of linking theory to application (Rammund-Mansingsh & Reddy, 2021). Additionally, the unique combination of chemistry knowledge and entrepreneurial skills is underpinned by the Chemical Entrepreneurial Pedagogical Model. The model advocates for equal emphasis on pure chemical knowledge and entrepreneurial principles with a specific focus on the intersection leading to innovations, and developing new products, processes or businesses (Nizhenkovska et al., 2020). The model further alludes to that the acquired entrepreneurial skill set are market research, business strategy, finances, operations and leadership. Thus, aligns entrepreneurship education with an entrepreneurial mindset.

**Methodology**

**Research framework**

The paradigm that applies to this research is the constructivism paradigm, also known as interpretivism, symbolic thinking, or hermeneutics. According to its proponents, knowledge is a mental representation, and there are multiple ways to represent a situation (Creswell & Creswell, 2017). To understand social reality, insiders' viewpoints are crucial. This paradigm is relevant to the study as it seeks to understand whether entrepreneurship education can stimulate entrepreneurial mindset.
Research approach

The research approach employed is a qualitative narrative literature review. This approach corresponds to the interpretative qualitative paradigm, which maintains that there are several realities that may be discovered via searching for literature (Creswell & Creswell, 2017). As found in the literature there are many views regarding the sustainability of SMMEs, especially concerning corporate governance. Consequently, it was decided that the search for pertinent topics in a variety of publications was acceptable for the research. The desktop methodology employed where the thematic succeeding narrative analyses are utilized.

This methodology expands on prior knowledge (Terry et al., 2017). It is a systematic way of synthesizing knowledge, especially when arranged into themes that respond to the research question at hand (Snyder, 2019; Osorio et al., 2020). Can entrepreneurship education stimulate an entrepreneurial mindset in Chemistry students? The themes explored to provide insight into existing literature about answering the question are graduate attributes and employability, science-based entrepreneurship education, and entrepreneurial mindset.

Findings and Discussions

The thematic analysis of the literature search for alignment between entrepreneurship education and entrepreneurial mindset yielded the following themes: graduate attributes and employability, science-based entrepreneurship education and entrepreneurial mindset. Hence, the following sections elaborate on the findings.

Graduate attributes and employability

The principal objective of further learning is preparing students for employability in a highly global competitive market for jobs. Graduates must exhibit the abilities, traits, and characteristics that employers appreciate most in order to become more employable, which include competency in the curriculum provided (Kaminski et al., 2009; Kivunja, 2014). The same applies to chemistry students, whereby HEIs need to continue the useful efficacy of chemistry courses and investigate the degree to which graduate characteristics, accreditation standards, and industry employability correspond as a means to adapt to industry revolutions (Kivunja, 2014, Sarkar et al., 2020). Not forgetting academic discipline has its own epistemic culture, a culture that produces and defends knowledge, and which is made up of the processes that constitute our knowledge and our understanding of it (Mncayi, 2016).

The industry and policymakers are investing in soft skills as an attribute to building flexibility and aiding recovery following the COVID-19 outbreak (Caselli et al., 2022; Hayat et al., 2022). This is maintained by fulfilling and needing experts who can meet the most recent developments and circumstances, such the Fourth Industrial Revolution (Schwab, 2016). But still, HEIs are frequently disapproved of failing to prepare graduates for the practical settings in which they will operate as professionals (Mohee & Putty-Rogbeer, 2020; O’Neill et al., 2021). In this context, graduate employability is a central issue in driving the mission of HEIs (Small et al., 2018). Consequently, HEIs adopted strategies to mitigate the identified challenges such as volunteering for exposure to the labour market, mentoring programs, career guidance services, and reinforcing graduate attributes through curricula such as entrepreneurship courses and extra curricula activities (Finch et al., 2013; Ntale, 2022).

An international study of chemistry graduates found that many of them valued and believed that general skills were more useful than academic knowledge (Hanson & Overton, 2010). Studies found a disparity between degree programs’ skill development and graduates’ utilization of such talents in the scientific and non-science industries reports identified an inequality between the development of skills within degree programme’s and their use following graduation for both science and non-science sectors (Lowden et al., 2011). In addition to demonstrating a variety of soft skills and attributes like teamwork, communication, leadership, critical thinking, problem-solving, and managerial abilities—all of which are more important in the workplace than disciplinary knowledge—a graduate must possess discipline-specific knowledge and skills from their degrees (Ferns 2012; Sarkar et al., 2016; Mohee and Putty-Rogbeer, 2020; Wong et al., 2021). The skills for employability listed by Sarkar and others highlight the importance of the capacity to elucidate the function and importance of science in society, awareness within the business industry, a capacity for adaptability and flexibility, and ICT skills (Sarkar et al., 2016).

The chemistry program teaches all-encompassing writing, oral communication, collaboration, and solving complex problems. The other employability skills are deemed as the discrepancy between employers’ expectations and chemistry students’ abilities. Hence, responsive and proposed undergraduate chemistry curricula must emphasize not just discipline-specific abilities and topic understanding, but also cross-disciplinary talents. Scientific researchers need to be able to communicate both verbally and in writing with the public and other scientists. (Adedokun et al., 2013; Heron et al., 2016). The mentioned skills contribute to cross-disciplinary skills which are labelled as inclusive employability skills, soft skills, or 21st-century skills (Rosenberg et al., 2012; Finch et al., 2013; Jang, 2016). The preceded attributes are fundamental characteristics for employability in hiring new graduates (Lievens & Sackett 2012; Finch et al., 2013).

Science-based education in entrepreneurship

Entrepreneurship education is at the center of the entrepreneurial universities debate. However, there is still a lack of consensus with regard to course content, pedagogy and learning outcome particularly for programs that do not consider entrepreneurship education as one of the majors (Foyalle et al., 2021). The challenge stems from the course being offered to different students with different
Entrepreneurial mindset

Globally, the need to be multi-skilled with ICT, communication and entrepreneurship is becoming more intriguing in the existing high unemployment and saturated labour market. Chemistry is described as the investigation of matter, energy, and their interplay. Currently understood to include the characteristics of matter, how and why different compounds mix or separate to generate new substances, and the ways in which different substances interact with energy (Bagley 2014). Chemistry is mostly used in different fields of human activities such as engineering, pharmacy, agriculture and medicine. Requiring qualitative functioning of chemical knowledge which is practical and useful in reflecting on the immediate social environment and developmental needs (Suleiman, 2010). Chemistry is found in all of our human activities we experienced daily and this field has advanced in areas of biochemistry, prosthetics sciences, supramolecular chemistry and nanoscience, bio and solar fuels, computational chemistry, synthesis and analytical sciences, electrochemistry among others, have made human life more relaxed. Chemistry education has provided students with functional education and continued to produce unskilled entrepreneurship or business-minded graduates who can innovate and contribute to labour markets and industrial market demands. Entrepreneurship skill encouragement creates value by devoting time associated with financial rational and societal hazards, as well as obtaining the growing incentives of the majority subjective compensation (Abdu, 2010). Entrepreneurship encompasses graduates' thoughts are directed toward the business and independent worlds through the identification of a market and the mobilization of essential resources to service a market. This increases innovation, inventiveness and the growing proportion of employers rather than workers and a stable national economic growth and stability. Our society is experiencing application challenges in chemistry, in which employment demand for graduates to have soft skills which allow them to contribute towards innovation and enterprise (Melin & Correll, 2022). Our institutions of learning are not focusing to produce graduates who are equipped in dealing with future improvements and entrepreneurial attributes such as failure (Chell 2013). Higher education focuses on academic success and assessments. Students awareness about innovation and problem solving skills need to be instilled as they are associated with entrepreneurship and skills are important within the chemical industries.

Students who have an education in entrepreneurship are more prepared to handle the difficult situations that arise when they pursue their own business ventures (Tittel & Terzidis, 2020). Resilience abilities and the ability to deal with, adjust to, and overcome hardship, indecision, and change. Entrepreneurship's effects in chemistry assists in identifying and researching about under describe pedagogies (Nabi et al. 2017). In which failure to account for preparedness related to emotion and mentality known as constructive debate in management, business, and entrepreneurial education (O’Neill et al. 2021). Due to this, there are now chances in the field of scholarship of teaching and about the integration of ideas and models from philosophy and education with experiential pedagogies to accomplish possible results in chemistry (Byrne et al., 2014). This will include instructing, experimenting with methods for resolving emotional problems and learning from mistakes (Loi et al., 2016). This will reduce the gap between theory and practice (Mwasalwiba, 2010; Naia et al., 2014). This will increase the trends in entrepreneurship education such as positivism, objectivism, and rationality. The application of behaviorism, cognitivism, constructivism, and humanism to support and underpin learning is highlighted by entrepreneurial education theory and learning (Bell, 2021). In which learner-centered production of meaning from information and the development of the full person are prioritized in entrepreneurship approaches with philosophical leanings toward constructivist and humanistic education.
Apparently, a course of study where students of science and engineering created a new venture, were introduced to entrepreneurship (Lackeus & Middleton, 2015). This study aimed to compare and evaluate the impact of entrepreneurship education on the entrepreneurial goals of science and engineering students with those of business administration students. Demonstrating that, in contrast to business administration students who are unaffected, science and engineering students suffer from environmental effects. This is evident of cognitive theories of learning which focuses beyond observable behaviours and at how information is received, organized, stored, and retrieved by the mind (Baron 2008). How risky and fundamentally unpredictable entrepreneurial processes impact emotions and have a significant impact on entrepreneurial outcomes. Students are learning how to solve problems, think creatively, and deal with failure. In which students are active participants in the center of their own learning process and entrepreneurship educators should primarily concentrate on ideal affective-cognitive models of learnings. This is linked with diverse approaches to entrepreneurship education learning outcomes of how it is thought and framed by teachers (Fayolle & Gailly, 2015).

As a result, there will be a greater emphasis on self-efficacy in pedagogies that emphasize entrepreneurial attitude and focused knowledge pedagogies on how to launch a firm.

Conclusions

The study aimed to evaluate whether the offered entrepreneurship education to chemistry students stimulates an entrepreneurial mindset. The qualitative narrative literature review methodology and the connectivism learning theory were used to achieve the set aim. The literature review revealed a correlation between graduates’ attributes and employability while linking an entrepreneurial mindset as a learning outcome of entrepreneurship education. The study findings suggest that a science-based entrepreneurial education approach be adopted whereby science concepts are embedded in the entrepreneurship education curriculum for familiarity, easy understanding of concepts and applications in real-life scenarios. For instance, applying chemistry knowledge in devising a water treatment solution for remote rural areas in South Africa that has the potential to be income-generating.

The creation of an undergraduate work-related activities program is the result of entrepreneurial education improving work-related research skills. This will facilitate in employment performance-based skills on what is required from graduates. This will equip students to attain skills, and readiness through the use of university-developed knowledge, abilities, and capabilities in the workplace. The skills should be developed at university degree programs, through curriculum reformation. This will improve the employability of graduates creating their own innovative business structures and ability to retain and secure employment. As well as improving productivity and income-earning prospects and as well learning to learn outcomes. This is in addition to the concept knowledge of skills which is marked, exhibits personal traits and values, as well as a thorough comprehension of skillful activities and the capacity to constructively reflect on events. This is on top of knowledge of the chemical subject, transferable skills, people’s confidence in their abilities to change the world, their self-awareness of their learning, and their capacity to reflect on how they conceptualize employability. This will help institutions of higher learning create an institutional narrative around employability. As well as identifying solutions to complex societal problems which involve transdisciplinary approaches and competencies. In addition, these are initiatives that prepare graduates for their professional practice which is directed towards an environment of uncertainty and constant change. This advancement will support science-based entrepreneurial education programs by facilitating university-industry technology transfer, which is essential for the future. In terms of commercializing technology and generating value for society through technical innovation, this will be a fruitful investment in the innovation system. This means that various initiatives and programs at universities ought to aim to support students in realizing their greatest potential in terms of their academic, professional, and personal lives. Assessing the challenges faced by the labor market would also provide career progression and a smoother transition for graduates of tertiary education institutions into the workforce

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