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Practical-Based Chemistry for Entrepreneurial Mindsets Among Secondary Schools in Ilemela Municipality, Tanzania

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Abstract
This study investigated the impact of practical chemistry on students' entrepreneurial mindset and knowledge. It employed a quantitative approach with a randomized posttest-only control group design, which randomly assigned 205 respondents at the student level into control and experimental groups. Block randomization based on prior exposure to ceramic and laundry soap-making activities and academic ability was used to ensure group similarity. It involved random sampling to get schools (N=4) and purposive sampling for respondents from science classes. Likert scale questionnaires and observational checklists were used to measure students' entrepreneurship mindsets, while an achievement test was used to measure entrepreneurship knowledge. Independent sample t-test revealed a significant mean difference in entrepreneurial mindset between experimental (M_1= 4.3) and control (M_2=2.4) groups with t (205) = -29.84, p < 0. 001. While the eta squared value of 0.81 implied a large effect size. Additionally, chi-square findings with a p< 0.001 revealed significant impacts of practical activities on entrepreneurial knowledge. This suggests that the practical applications of chemistry significantly impact students' entrepreneurial mindsets and knowledge; therefore, it is recommended to incorporate entrepreneurship activities into the chemistry curriculum.
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1. Introduction

The lack of employability skills among school graduates has drawn global concern, as many graduates with limited employable skills have been reported (Ahmad et al., 2014). This has been attributed to deficiencies in education systems, specifically its failure to meet the demands of the job market by producing graduates with limited skills and competencies (Rajeev et al., 2017). The most affected group is youth where it is estimated that youth unemployment climbed to 6% globally between 2019 and 2023 (ILO, 2024). Unemployment uncertainty was also addressed in sustainable development goals, especially goal number 8 which emphasized the acquisition of skills for decent work and economic growth to be attained by all nations by 2030. These skills included creativity, innovation, problem-solving abilities, soft skills, and other important life skills to make the world a conducive place for living (Johnston, 2016). Similarly, youth as a source of energetic manpower need to be equipped with these skills to develop self-efficacy towards job creativity. To apprehend this, the emphasis on entrepreneurship education is of paramount importance for addressing some unemployment issues among graduates by encouraging job creativity skills in schools (Johnston, 2016).

Chemistry has a strong correlation with the creation of opportunities that may encourage entrepreneurial spirit. However theoretical chemistry education has obscured many potential career paths in the field. As an important part of science, technology, engineering, and mathematics (STEM), chemistry classes should incorporate entrepreneurial mindsets and practices to help students produce the kind of inventive ideas and products that can be commercially successful. Runge and Bräse, (2008) assert that the practical application of chemistry

entrepreneurship is important in opening opportunities such as the development of different chemical industries which could facilitate job creativity and economic growth. For example, the development of waste management projects, soap making, nanotechnology, water treatment and purifications, food industry, and agrochemical industries. These support the development of entrepreneurship behaviors among learners which could pave their way for job creativity after graduation (You et al., 2017). Chemistry provides a platform for young scientists to develop different innovative products at school and test them (Chemistry Education Research and Practice, 2017). Ceramic cleaners and laundry soap making could foster students' marketing strategies and product development skills which are important for the establishment and development of business ventures.

By observing the potential of STEM subjects, including chemistry, in developing entrepreneurial mindsets within the education system, various organizations are providing support to facilitate this. For instance, Global Entrepreneurship Week promotes innovation and creativity by encouraging entrepreneurs from around the world to participate in competitions, particularly those based on science and technology exhibitions (Sheffield et al., 2018). This promotes the development of innovative scientific ventures, networking as well as improved marketing strategies through exposure to different entrepreneurship occasions. The African Entrepreneurship Awards, founded by the Bank of Africa, serve similar purposes in African countries as those of Global Entrepreneurship Week. Likewise, the East Africa Science and Technology Commission as well as the Tanzania Commission for Science Technology (COSTECH), continue to promote scientific entrepreneurship in Tanzania (Rajeev et al., 2017). Additionally, Young Scientists, a unique program designed to encourage science students to create creative scientific projects, particularly in chemistry, inspires students' creativity and problem-solving skills (Khan et al., 2012).

Furthermore Dike and Avwiri (2020) added that exposing learners to scientific projects that are linked to entrepreneurship could reveal some economic benefits of chemistry and promote their entrepreneurship mindsets. Additionally, Susianna (2011) insists that chemistry teachers need to be innovative by encouraging experiential learning. Promoting innovative learning by shifting from a teacher-centered approach to a student-centered one, while incorporating entrepreneurship aspects, helps foster students' entrepreneurial mindsets (Toit & Ntimbwa, 2023). Chemistry-based entrepreneurial mindsets are hindered by complex theoretical concepts and the omission of practical applications, making the subject complex and disconnected from other fields. This limits students' creativity and potential career opportunities (URT, 2017). This resulted in the persistence of unemployment issues among graduates (Thuo et al., 2016). This study aimed to fill this gap by evaluating the influence of integrating practical activities to enhance entrepreneurial mindsets and understanding among secondary school science students. The study intended to investigate the relationship between chemistry education and the development of an entrepreneurial mindset and assess entrepreneurship knowledge and understanding among secondary school students.

1.1 Research hypothesis

H_{01}: There is no significant relationship between chemistry practical and entrepreneurship mindset cultivation between control and experimental groups.

H_{02}: There is no significant association in the level of knowledge and understanding of entrepreneurship concepts and chemistry practicals between experimental and control groups.

1.2 Theoretical Framework

1.2.1 The theory of planned behavior (TPB)

The theory of planned behavior (TPB) was first introduced by Ajzen and it has been widely used to explain and predict human behavior in various fields, including entrepreneurship education (Ajzen, 1991). According to the theory, mindsets, subjective norms, and perceived behavioral control are the main factors that influence an individual's intention to engage in a particular behavior, which leads to the actual behavior. Mindset is an evaluation of personal behavior by being willing or unwilling towards a particular practice. A positive mindset leads to the development of actual behaviors (Domilescu, 2019). In the process of ceramic cleaner and soap-making activities, students with positive mindsets towards these activities are likely to participate actively and

consider these activities as useful for their career pathway. The theory highlights the importance of facilitating students' mindsets to excel in entrepreneurship activities.

Subjective norms refer to individual perceptions of how others perceive a behavior, for example, family members, religious groups, teachers, peers, and others. Approval from influential groups accelerates the development of an actual behavior while their disapproval diminishes a behavior. Perceived behaviors are internal or external perceptions about an individual ability to perform a particular behavior. It includes internal forces like self-efficacy or external factors such as the availability of resources and relevant skills to perform a behavior. In this study, all three factors were considered in cultivating entrepreneurship behaviors among students. Students were assessed on their entrepreneurship mindsets, knowledge, and understanding. They were motivated by the potentialities of engaging in entrepreneurship activities and facilitation of product-making activities to equip them with relevant skills and knowledge that are expected to change or strengthen their attitudes and raise their self-efficacy.

2. Material and Methods

2.1 Research approach

The present study employed quantitative methods, a method considered useful for collecting large data and providing numerical values that are easy to interpret with minimal bias (Creswell, 2009). Also, it provides quantifications of relations which makes conclusions based on arithmetical data such as mean, percentages, and frequencies and equips a researcher with statistical tools to test hypotheses, providing knowledge on relationships (McNabb, 2018) The randomized posttest-only control group design was used to explore the influence of the practical application of chemistry on students' entrepreneurship mindsets, as the design seemed to be effective in eliminating some threats to internal validity such as test effects, history as well as maturation (Moazami et al., 2014: Lightner et al., 2023: Jackfraenkel, 2014)

2.2 Participants

The sample involved 205 respondents from Form Four science students. Simple random sampling employed the lottery technique to select four schools from Ilemela Municipality, and purposive sampling was used to get form four students pursuing chemistry from each school. Randomly assignment of respondents was conducted at the student level into control and experimental groups. Block randomization into groups of characteristics such as previous subjection to ceramic and laundry soap-making activities and academic abilities. From a block of characteristics, groups were further classified by systematic sampling to obtain the experimental group (N_1=101) and control group (N_2=104), to ensure equality in groups in terms of respondent characteristics. From the experimental group, 17 subgroups were randomly formed from experimental groups, each comprised of almost 6 respondents involved in ceramic cleaner and soap-making activities. A control group was doing regular class activities. Both groups were tested, and later control group received similar treatment as the experimental groups after data collection (Jackfraenkel, 2014).

2.3 Data collections

A brief information on ceramic cleaner and soap making process and all procedures were provided in the user guide (see appendix). Students were provided with necessary reagents for ceramic cleaner and laundry soap making including Hydrochloric acid, surfactants, distilled water, plant oil, caustic soda, caustic potash, and other additives.

2.3.1 Making Laundry Soap

In making laundry soap the following reactions were involved as guidelines

$$CH_3COOC_2H_{5(l)} + NaOH(aq) \longrightarrow CH_3COONa(s) + C_2H_5OH(l)\text{----------}(1)$$

$$CH_3COOC_2H_{5(l)} + KOH(aq) \longrightarrow CH_3COOK(s) + C_2H_5OH(l)\text{----------}(2)$$

2.3.2 Tools used

Participant observational checklist was used to collect observational data reflecting entrepreneurship traits, knowledge, and understanding rated 1 to 3 (low to high) also Likert scale questionnaires ranging from 1 to 5 (low to high) were used to assess entrepreneurship mindsets. Similarly, the Achievement test was used to measure entrepreneurship knowledge and understanding.

2.4 Data analysis

The process of data analysis involved data entry in SPSS version 25, data cleaning in which data were corrected by removing some typographical errors, and identifying some missing values, and removing some duplicates. Data were then transformed into an analyzable manner. Frequencies, variances, percentages, and standard deviation were used to answer research questions, while independent sample t-tests and chi-square tests were used to test a research hypothesis. A t-test measured at a 95% confidence interval was used for testing a null hypothesis. Eta squares were used to describe the effect size.

2.5 Ethical considerations

The research study accurately adhered to all essential measures in addressing ethical concerns. Before commencing the study, approval and permits about ethics were acquired from both the University and the President's Office Regional administration and local government of Tanzania (PO-RALG), guaranteeing adherence to ethical guidelines and regulations governing research involving human participants. The study was carried out following the approved protocols, ensuring the maintenance of participants' privacy, confidentiality, and well-being throughout the research process. Willingly participation of respondents was highly achieved. Before publication, Students provided orally informed consent for participation and written consent for using their practical work in this study for publication. To ensure academic integrity expected learning outcomes were clearly stated to all students as well as the evaluation mechanism. Environmental protections were given priority by using less hazardous chemicals and also emphasizing students' precise and neat working environment.

3. Results and Discussions

3.1 Demographic characteristics of study participant

The study included 205 respondents from four science students from Ilemela municipal secondary schools. It consisted of experimental and control groups. The experimental group contained 104 respondents, while the control group had 101 respondents. Each variable distribution has been analyzed by showing its frequency and percentage. Table 1 represents the demographic characteristics of the study sample.

Table 1: Demographic distribution of respondents

Variable name	Sub variable	Frequency	Percentage (%)
1. Sex	Male	108	52.7
	Female	97	47.3
2. Participant Group	Control	101	49.3
	Experimental	104	50.7
3.School Name	Mnarani	62	30.2
	Kitangiri	59	28.8
	Rorya	43	21.0
	Sunrise	41	20.0

3.2 Students' Practical evaluation on entrepreneurship Traits

Entrepreneurial traits revealed by students throughout practical sessions were studied. To apprehend this, practical observations based on students' innovation and creativity, resilience and adaptability, and collaboration and communication during the ceramic cleaner and laundry soap activities were conducted. Innovation and creativity involve the ability to create products, use any additional materials, and the packaging of materials to improve quality and enhance marketing. Resilience and adaptability include the ability to withstand unexpected challenges during practical activities and be flexible towards any unforeseen changes. Finally, collaboration and communication involved active participation in practical activities, necessary communication between students and teachers, and responses to frequently asked questions by teachers for further clarification of which their results were presented in Fig.1. Results on the innovation and creativity traits indicated that 52% of the responded demonstrated satisfaction, 29% needed more improvement, and 19% excellent while in resilience and adaptability, 48% of the responded portrayed satisfactory, 23% needed more improvements, and 29% excellent. Furthermore, for collaboration and communication traits, the results showed that 46% of the respondents indicated satisfaction, 12% needed more improvements, and 42% showed excellent performance. Overall, 71% of the participants showed high levels of innovation and creativity, displaying both average and exceptional performance in those areas. Additionally, 78% of the respondents exhibited good performance in terms of resilience and adaptability while 88% demonstrated proficiency in collaboration and communication. This implies that hands-on activities have a significant contribution to the development of entrepreneurship knowledge and mindsets among students.

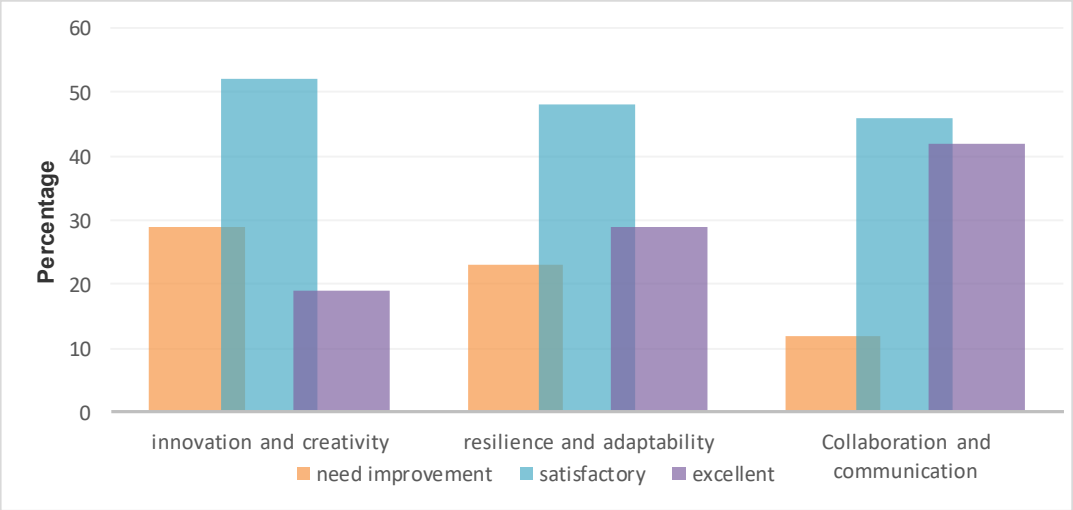

Figure 1: Performance in entrepreneurship traits revealed during the practical Session

Innovation and creativity are essential for success in the highly competitive soap and ceramic cleaner entrepreneurial business. To differentiate themselves, entrepreneurs must provide different, effective, and customer-specific products that need creativity in formulation, packaging, and marketing. Sustainability is also important, with customers demanding eco-friendly solutions that drive innovation in natural ingredients, biodegradable formulae, and environmentally friendly packaging. Innovation can also lead to cost-effective manufacturing methods, such as using readily available materials or establishing new, efficient processes, allowing for competitive prices while preserving quality. For instance, in terms of innovation and creativity, respondents from groups 4 and 7 added vitamin C to their product by using additions like lemons, while other groups used neem and lemon grass to enhance the skin's moisture and scent. Therefore, innovation and creativity traits triggered students' entrepreneurial skills which helped them to demonstrate their ability to use several ingredients, including coffee, oranges, bananas, turmeric, and grapefruits, to increase the soap's aroma and

distinctiveness. Their competence for innovation and creativity in this area may influence their mindsets and willingness towards engagement and establishment of business ventures. Also, responding to changing customer preferences and cleaning demands necessitates innovation, which results in new product lines, responding to rising trends, and developing new approaches to specific cleaning issues. The importance of innovation and creativity in inspiring entrepreneurship has been reported by other scholars. Studies conducted by Fitriati et al. (2020) and Mazla et al. (2020) reported on the importance of innovation in the entrepreneurship sector, illustrating the necessity for product differentiation, cost-effectiveness, and market adaption to ensure growth and sustainability.

Innovation and creativity are high indeed in the competitive entrepreneurial landscape, particularly in industries like soap and ceramic cleaner production. Entrepreneurs in such sectors must continually innovate to offer unique, effective, and environmentally friendly products that cater to evolving customer preferences. The integration of sustainability practices, such as using natural ingredients and eco-friendly packaging, is crucial in meeting consumer demands for environmentally conscious solutions. The link between innovation, creativity, and entrepreneurship is well-documented in the literature, For example Mazla et al., (2020) focused on the role of innovation in responding to changing consumer trends, stressing the need for entrepreneurs to continuously develop new product lines to meet evolving demands.

In this study, the incorporation of innovative ingredients like vitamin C, neem, lemon grass, and other natural elements in soap production revealed the students' entrepreneurial creativity and ability to differentiate their products. This aligns with previous research findings that link innovation and creativity to entrepreneurial success. The students' demonstration of competence in product innovation and creativity not only enhances the quality of their products but also influences their entrepreneurial mindsets, fostering a proactive approach towards business ventures. The findings of this study align with existing literatures on the significance of innovation and creativity in entrepreneurship. However, the unique aspect of this study lies in the practical application of innovation and creativity within the soap and ceramic cleaner production context. By actively engaging students in product development and encouraging them to explore diverse ingredients and scents, the study goes beyond theoretical discussions to provide practical insights into how innovation and creativity can drive entrepreneurial success. The current study emphasizes the critical role of innovation and creativity in inspiring entrepreneurship, particularly in industries where differentiation and sustainability are key success factors. By implementing on a combination of innovative formulations, packaging strategies, and market adaptation, entrepreneurs can not only meet customer expectations but also pave the way for sustainable business growth. The practical application of innovation and creativity in soap and ceramic cleaner production demonstrates how these traits can empower aspiring entrepreneurs to navigate competitive markets and establish successful ventures

The collaborative nature of the practical exercises in this study, characterized by active engagement, mutual assistance, and shared decision-making, played a crucial role in fostering entrepreneurial mindsets among students. This finding aligns with a growing body of literature that emphasizes the importance of collaboration and communication in promoting entrepreneurial success. For instance, Bhattacharyya (2010) found that collaborative learning environments, where students actively engage in problem-solving and knowledge sharing, significantly enhance their entrepreneurial self-efficacy and innovation skills. Similarly, Jennifer et al., (2022) highlighted the role of communication in entrepreneurial ventures, arguing that effective communication networks facilitate resource mobilization, knowledge transfer, and market access, all of which are essential for business success. While the current study supports the positive influence of collaboration and communication on entrepreneurial development, it also highlights a unique aspect of this process. The emphasis on peer feedback and encouragement, where students assessed each other's work and provided constructive criticism, distinguishes this study from previous research. This element of peer evaluation, coupled with the provision of guidance and motivation, further strengthens the development of entrepreneurial skills by fostering a culture of continuous improvement and self-reflection. This aspect of the study aligns with Shaughnessy et al., (2023), which explored the impact of peer feedback on student learning. The study found that constructive peer feedback, when delivered in a supportive and encouraging environment, significantly improved student performance and motivation. Generally, the findings of this study emphasize the overall

nature of collaboration and communication in fostering entrepreneurial mindsets. While the study confirms the importance of these factors as previously reported in the literature, it also highlights the unique contribution of peer feedback and encouragement in promoting entrepreneurial growth. This suggests that incorporating these elements into educational practices can further enhance students' entrepreneurial development and prepare them for future success in the business world.

The practical activities in this study fostered resilience and adaptability in students, crucial traits for entrepreneurial success. The ability to navigate unexpected challenges, adjust strategies, and respond to changing market demands is essential for entrepreneurs to thrive in a dynamic environment. The study's findings align with existing research on the importance of resilience and adaptability in entrepreneurship. For example, Conduah and Essiaw, (2022) found that entrepreneurs who exhibit high levels of resilience are better equipped to overcome setbacks and capitalize on opportunities, leading to greater business success. Similarly, Hartmann et al., (2022) highlighted the role of adaptability in responding to changing market conditions, emphasizing the need for entrepreneurs to be flexible and responsive to customer needs and industry trends. The study highlights the practical application of resilience and adaptability in an entrepreneurial context through several compelling examples. One group, faced with changing customer preferences, successfully transitioned from palm kernel oil to olive oil, demonstrating their ability to adjust strategies based on market feedback. This adaptability is crucial for entrepreneurial success, as it allows businesses to remain competitive and responsive to evolving consumer needs. Another group showcased remarkable resilience by transforming a failed soap product into a successful liquid soap. By adding more reagents and enhancing the fragrance, they turned a setback into an opportunity for growth. This example illustrates the importance of learning from mistakes and finding innovative solutions to overcome challenges.

While the study aligns with existing literature on the importance of resilience and adaptability in entrepreneurship, it also highlights a unique aspect of the ceramic cleaner and laundry soap-making process. The focus on practical application within the soap and ceramic cleaner production context provides valuable insights into how resilience and adaptability can be developed through practical learning experiences. By actively engaging students in the production process and encouraging them to solve real-world problems, the study demonstrates how these entrepreneurship traits can be developed practically and engagingly. The study highlights the importance of resilience and adaptability in fostering entrepreneurial mindsets and behaviors. The findings align with existing research on the significance of these traits in entrepreneurial success, but the study's focus on practical application within the soap and ceramic cleaner production context provides a unique perspective on how these traits can be developed through practical learning experiences. This suggests that incorporating practical activities that promote resilience and adaptability into educational programs can effectively prepare students for the challenges and opportunities of the entrepreneurial world.

3.3 Relevance of Chemistry in Creating Innovative Business Solutions

The importance of chemistry subjects in the creation of innovative business solutions was investigated in this section. Chemistry plays a crucial role in the production of several commercial items, including soap, body lotions, and skincare products. Gaining knowledge of various chemical principles, such as reaction mechanisms, can facilitate the production of high-quality products that align with consumer requirements. Participants were evaluated based on their reaction to chemistry in developing creative commercial solutions. Figure 2 represents students' responses toward the role of chemistry in the creation of innovative business solutions between control and experimental groups.

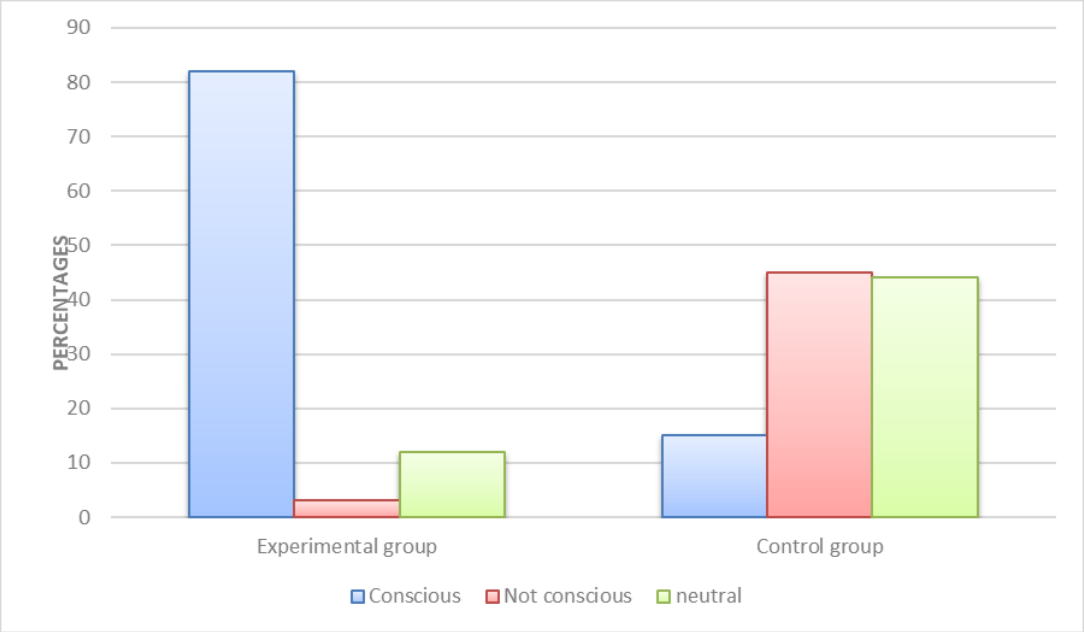

Figure 2: Relevance of chemistry in creating innovative business solutions

The study's findings, as illustrated in Figure 2, reveal a significant disparity in awareness regarding the relevance of chemistry in developing innovative business solutions. A substantial majority (85%) of respondents in the experimental group demonstrated awareness, highlighting a strong understanding of the potential of chemistry in entrepreneurship. Conversely, the control group exhibited a limited awareness of the role of chemistry in the creation of business solutions, with only 15% recognizing its importance. This difference in awareness highlights the crucial role of practical interventions in fostering a chemistry-based entrepreneurial behavior. This observation aligns with the findings of Epinur et al., (2022) who argue that a lack of awareness regarding the potential of chemistry in business innovation hinders entrepreneurial activity. They suggest that incorporating chemistry-focused entrepreneurship education into curricula can bridge this gap and empower individuals to apply chemical principles for business growth. The study further emphasizes the practical applications of chemistry in addressing common business challenges. For instance, the use of chemical principles and reactions can significantly reduce operating costs and promote sustainability. This aligns with the work of Ncube et al., (2023) who highlight the importance of green chemistry in achieving sustainable business practices. They argue that by minimizing waste, reducing energy consumption, and utilizing renewable resources, businesses can achieve both economic and environmental benefits. For example, addressing sewage disposal issues and water impurities through innovative solutions like eco-friendly recycling procedures and 3D water purifiers demonstrates the tangible impact of chemistry in creating sustainable business models. These solutions not only address environmental concerns but also offer unique opportunities for entrepreneurial ventures.

Furthermore, the study emphasizes the potential of chemistry in addressing raw material scarcity and price fluctuations. By exploring alternative sources of raw materials through chemical concepts, businesses can ensure their long-term viability and resilience. This aligns with the work of Dike et al., (2017), who advocate for a circular economy approach, where resources are continuously reused and recycled. They argue that this approach, driven by chemical innovation, can significantly reduce dependence on limited resources and promote sustainable business practices. Generally, the study provides compelling evidence for the transformative power of chemistry in fostering innovation and driving business success. By bridging the awareness gap, incorporating chemistry-focused entrepreneurship education, and utilizing chemical principles for cost reduction, sustainability, and resource optimization, businesses can unlock significant opportunities for

growth and impact. The findings of this study, when compared with existing literature, emphasize the need for a holistic approach that integrates chemistry into entrepreneurial thinking and practice, paving the way for a more sustainable and innovative future.

3.4 Entrepreneurship knowledge and understanding

Students' knowledge and understanding of entrepreneurship based on their ability to recognize business opportunities in chemistry, Market research, compliance, calculated risk, marketing strategies as well as pricing and innovation in the chemical processing business were investigated and their results were presented in Tables 2 and 3.

Table 2: A participant group cross-tabulation on entrepreneurship knowledge

		Control groups	Experimental groups
LOW	Count	35	4
	Expected count	19.2	19.8
	% Within knowledge	89.7%	10.3%
MODERATE	Count	65	61
	Expected Count	62.1	63.9
	% Within knowledge	51.6%	48.4%
HIGHEST	Count	1	39
	Expected Count	19.7	20.3
	% Within knowledge	2.5%	97.5%

The Table 2 refers to test results conducted to evaluate the knowledge of entrepreneurship. The results showed that 89% of low performance was from the control group, while 10.3% was from the experimental group. Also, 51.6% of moderate performance were from the control group while 48.4% was from the experimental group. Furthermore, 97.5% of the highest performance was from the experimental group, while 2.5% was from the control group. Therefore, the results indicated that the experimental group had better knowledge and understanding of chemistry-based entrepreneurship than students in the control groups. The study revealed that hands-on activities, especially those involving practical applications of chemistry, significantly helped students understand entrepreneurship. This was evident in the strong association between practical activities and an entrepreneurial mindset, as shown in Table 3. The results indicated that students who engaged in hands-on activities were more likely to develop an entrepreneurial mindset. Specifically, the minimum expected count of 19.21 with a p-value less than 0.01 demonstrated a significant association between the practical application of chemistry and student understanding of entrepreneurship across different groups. This suggests that practical activities play a crucial role in fostering entrepreneurial knowledge and skills.

Table 3: Chi-square tests for entrepreneurship knowledge among students

Chi-Square Tests	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	60.837[a]	2	.000
Likelihood Ratio	74.455	2	.000
Linear-by-Linear Association	59.963	1	.000
N of Valid Cases	205		

[a] = 0 cells (.0%) have an expected count of less than 5. The minimum expected count is 19.21.

The ability to identify business opportunities from chemistry was among the aspects of entrepreneurship knowledge. Practical activities revealed associations in promoting entrepreneurship understanding among

students. Students in the experimental group were able to identify many small entrepreneurship opportunities that can be done at school as well as at home. This implies the development of entrepreneurship knowledge and mindset. The study's findings align with previous research highlighting the effectiveness of hands-on activities in promoting entrepreneurship knowledge and skills (Dike & Avwiri, 2020). Similar to other studies, this research emphasizes the importance of practical experience in developing an entrepreneurial mindset and fostering the ability to identify business opportunities such as the study by Onah et al., (2020) and Sari et al., (2023). However, this study goes beyond simply identifying opportunities, and delving deeper into the practical aspects of marketing and financial management. Unlike some studies that focus solely on the identification of business opportunities, this research emphasizes the crucial role of market research and effective marketing strategies in entrepreneurial success. Students were actively engaged in gathering customer feedback, analyzing competitor products and pricing, and implementing strategies to gain market share. This emphasis on practical marketing skills aligns with research by Fitriati et al., (2020) which suggests that effective marketing is a key driver of entrepreneurial success. Furthermore, the study highlights the importance of financial management skills in entrepreneurship, a crucial aspect often overlooked in other studies. By bridging theoretical knowledge with practical experience, the study provides a comprehensive approach to fostering entrepreneurship knowledge and skills, aligning with the growing body of research advocating for practical learning in entrepreneurship education (Kira, 2017). This research contributes to the understanding of how practical activities can effectively equip students with the knowledge and skills necessary for success in chemical commercialization and beyond the classroom.

Additionally, students developed their marketing strategies through practical exercises. Emphasis was placed on the importance of conducting market research and developing a marketing strategy as an important skill for understanding entrepreneurship. It entailed asking customers for evaluations and feedback, interviewing them to get their opinions, and seeing how they responded to the manufactured goods. Students had to comprehend that there may be other businesses operating in the same industry as theirs; identifying these competitors and the quality of their products would aid in investigating the goods, prices, and marketing tactics that must be employed to win market competition. Retaining customers with strategies like discounts, packaging, and bonuses for regular buyers helps businesses win over competitors in the market. Learners gained self-efficacy regarding their capacity to produce high-quality goods that customers, particularly their teachers, will accept, as well as an awareness of marketing methods. By bridging theoretical and practical knowledge, exposing students to significant entrepreneurship components could expand their career options and help them succeed in chemistry-based entrepreneurship.

3.5 Entrepreneurship mindsets

The results of the study, presented in Table 4, reveal a significant difference in entrepreneurship mindset between students who participated in hands-on activities (experimental group) and those who did not (control group). The experimental group demonstrated a significantly higher mean score (M_1 = 4.3) compared to the control group (M_2 = 2.4), suggesting a more developed entrepreneurial mindset among students who engaged in practical learning experiences. Furthermore, the data for the experimental group exhibited a lower coefficient of variation (9.8%) compared to the control group (22%), indicating that the scores for the experimental group were more tightly clustered around the mean value. This suggests a greater consistency and homogeneity in the development of entrepreneurial mindset among students who participated in practical activities.

Table 4: Group statistics comparison of mean on students' entrepreneurial mindsets

PARTICIPANT GROUP	N	Mean	Std. Deviation	Coefficient of variance
CONTROL	101	2.4	.5	0.22≈ 22%
EXPERIMENTAL	104	4.3	.4	0.098≈ 9.8%

Results in Table 5, show the value of t (205) = -29.8 which indicates a significant improvement in the score of student entrepreneurial attitudes between groups when practical applications of chemistry were used. The

significance level, $P < 0.01$, further supports this finding. According to the interpretations of eta squared, a result of 0.81 indicates a substantial effect size that is likely to be caused by a treatment.

Table 5: Independent sample t-test for student's entrepreneurship mindsets.

T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-29.84	198.282	.000	-1.865	.06253	-1.99	-1.74

Findings from Tables 4 and 5 reveal that chemistry entrepreneurship programs are effective in cultivating entrepreneurship mindsets among students. Sari et al., (2023) advocates that education practitioners need to motivate and empower learners with different practical activities to foster their entrepreneurship mindsets from grassroots levels to make them experienced with entrepreneurship activities. When students develop a positive attitude in entrepreneurship may strengths their assurance to pursue entrepreneurship as their career pathway. Secondary school students are at their stage of cognitive development and self-awareness, possess the maturity to consider their future aspirations as well as fulfillment of their ambitious goals and make informed decisions that will shape their career pathways, subjecting them to chemical-related entrepreneurship activities could make them curious on the benefits and enjoyments brought by chemistry knowledge (Deveci & Çepni, 2017). Chemistry teachers need to embed entrepreneurship within chemistry content by incorporating theoretical knowledge into the practical creation of new commercial products. This will likely reveal the economic potential of chemistry and spark their entrepreneurship mindset.

Entrepreneurship mindsets in chemistry can further be strengthened by support from parents, teachers, and fellow peers (Ajzen, 1991). Positive comments and encouragement on entrepreneurship as a viable career are likely to promote students' intention to pursue chemistry entrepreneurship activities (Mazla et al., 2020). During the production of ceramic cleaners and laundry soap, learners were encouraged to recognize the significance of distinctive products to succeed in a competitive market. This was achieved by conducting practicals with various additives to enhance the quality and distinctiveness of the soap. By offering learners various triglycerides with distinct saponification values, students were able to study diverse characteristics and visual aspects of the resulting soap. Therefore, students created a high-quality soap that does not cause any burning sensations for consumers. They achieved this by incorporating some additives such as Sodium silicate (Na_2SiO_3) and coconut diethanolamine (CDE) into the soap. Sodium silicate acted as a foaming agent, while CDE worked as both a foaming agent and a moisturizer for the skin. Teachers, peers as well as self-evaluation and appreciation for outstanding products made, motivated learners to practice more on laundry soap making and ceramic cleaners processing for business purposes. This is likely to develop student's entrepreneurship mindsets. The findings from this study align with those obtained by Kirkley, (2017) which engaged students in product making, hands-on activities observed to promote students' entrepreneurship mindsets. Also, a study conducted by Susianna, (2011) in Indonesia, which involved the synthesis of carbon and colloidal compounds yielded similar results to the findings of this study, this signifies the interconnection between practical applications of chemistry and entrepreneurship mindsets development. The findings of this study strongly suggest that engaging students in hands-on activities, particularly those involving practical applications of chemistry, can effectively foster the development of entrepreneurial mindsets. The significant difference in mean scores between the experimental and control groups provides compelling evidence for the positive impact of practical learning experiences. The interconnection between practical applications of chemistry and entrepreneurship mindset development emphasizes the importance of integrating hands-on learning into educational programs to cultivate future generations of entrepreneurs.

4. Conclusions and recommendations

The promotion of secondary school students' entrepreneurial mindsets is significantly linked to chemistry practical application. By practically applying chemistry concepts, students can expand their career horizons by learning how to make various goods with marketable qualities. It is recommended that policymakers incorporate entrepreneurship education into the chemistry curriculum to enable students to pursue entrepreneurship in relevant fields of chemistry. The report strongly recommends the participation of various stakeholders and successful entrepreneurs in the chemical industry to offer guidance and experience in starting new ventures as well as internships, to give chemistry-related young entrepreneurs important skills for starting their businesses. It is crucial to provide chemistry teachers with professional development so that they can guarantee experiential learning that stimulates creativity. It is important to incorporate evaluation techniques that encompass practical learning of entrepreneurship skills in the field of chemistry.

5. Limitations and future directions

The current study used a sample size of 205 and included students in form four. To increase study generalizability, a bigger sample size than this one that includes a varied range of science students from different educational levels could be more appropriate. Longitudinal studies should be carried out to look at long-term changes because a posttest-only control group design may not be able to identify the long-term impacts of real-world chemical applications on entrepreneurship mindset cultivation due to the lack of regular follow-up. Engaging in diverse activities such as oil extraction, manufacturing of agricultural products, extraction of chemical compounds from plants, candle making, and natural cosmetics such as body scrub, Lotion, and shower gel may foster an array of knowledge, understanding, and professional opportunities within the field of chemistry.

A conflict of interest

The authors have no competing interests.

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APPENDIX

Introduction to the soap-making user manual

The goal of this handbook is to assist students in doing the soap-making process correctly and safely. To guarantee safety, follow all of the procedures and regulations outlined in this guide. Take these safety precautions:

1. Use safety goggles to shield your eyes from splashes and other chemical pollutants.
2. When handling hot items or Lye, wear heat-resistant gloves.
3. To protect your skin from chemicals, wear a lab coat and closed-toed shoes.
4. Work in a well-ventilated environment or fume chambers to prevent breathing gaseous emissions or wear industrial musk.
5. When mixing lye (caustic) with water, use heat-resistant containers.
6. Keep lye out of the hands of children and other domestic animals.
7. Label all chemicals and store them in a cool and safe place.
8. When mixing lye and oil be careful, it becomes hot. Stir gently to avoid splashing.
9. Clean up any spill immediately using safety measures.
10. Dispose appropriately of any waste and by-products

Procedures and materials for soap-making

Materials:

Distilled water, plant oil or animal oil, caustic soda, Protective gears, Digital scale, soap mold/shaper, fragrance, colorants, stir, Thermometer, hydroscope, Soap additives

Procedures:

Using a Digital balance measure the required amount of oil and Caustics (KOH/NaOH) for the soap recipe. Ensure accuracy in the following order:

Caustic soda or Potash	1kg	25kgs
Distilled water	3.5 litres	87.5 litres.

Using a measuring cylinder, measure triglyceride (oil) in the given ratios relative to caustic solutions (KOH/NaOH) and sodium silicate (Na_2SiO_3)

Oil (L)	LYE CAUSTIC SODA/CAUSTIC POTASH (NaOH/KOH) in L	SODIUM SILICATE (Na_2SiO_3) in mL
1	0.5	100
2	1	200
3	1.5	300
4	2	400
5	2.5	500

Mixing

Add a little amount of water to a heat-resistant container, then gradually add caustic soda (Lye) to form a solution while gently stirring and allowing it to cool. Prepare the oil in a separate container, pour caustic soda solution (lye) into the oil while blending with a stick blender. Continue blending until you reach 'trace'. (Until it thickens like custard). Add additives, such as sodium silicate, and blend. Add fragrance oil for scent and colorants (if desired). Put the mixed material into a mold. Molds made of wood, household containers, or silicone can all be used. Leave it uncovered to allow for evaporation and soap solidification. To cure a mold, keep it cool and dry for 24-48 hours. This makes soap tougher.

Cutting and unmolding

Using a knife or soap cutter, remove the soap from the soap mold and cut it into bars or the appropriate shape. Place the soap bar in a tray in a well-ventilated location. Allow the soap to cure for extra days. Once fully cured, mark your soap with the date and components used in its manufacturing.

Ceramic cleaners

Materials: Distilled water (H_20), Surfactants (Empigen), and Hydrochloric acid (HCl)

Procedures:

Take 15 L of distilled water and add 500 gm of Empigen. Add 5 L of hydrochloric acid and stir. When dealing with HCl, take precautions such as wearing gloves, safety goggles, a mask, and an apron or lab coat. Let the mixture cool for a few minutes and pack the product in the storage bottles, ready for use. Label for ingredients and manufacture date.