Integrating STEM Education in Uganda's Higher Education to Produce Skills Required to Stimulate Industrialisation and Sustainable Economic Growth

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Abstract

The high cost of education, coupled with the high rate of unemployment, is a major concern for developing countries, including Uganda. The economic growth of any developing nation heavily relies on its capacity to create sustainable job opportunities across various sectors. An education based on Science, Technology, Engineering and Mathematics (STEM) can serve as a powerful driving force to overcome barriers and achieve this crucial milestone. The traditional methods of teaching, learning and research in higher institutions of learning (HIL) in Uganda mainly emphasise theoretical knowledge rather than practical skills development. This leads to a wider gap in the skills required of graduates for job creation, industrialisation and stimulating economic growth. This study aims to investigate the key factors that should be considered for the effective integration of STEM education into Uganda's higher education (HE) in relation to the needs of industry and community development. By adopting integrated STEM education, we envision that empowered graduates will become innovators and job creators. To gather comprehensive insights into the perception of integrated STEM education in HIL, qualitative data was collected from 42 respondents using an online semi-structured questionnaire. The data was analysed using descriptive statistics. The study established that although some integrated STEM education exists in academia, industry and the community, its full integration is limited by the inadequacy of quality staff, funding and the rather weak collaboration and partnership between academia, industry and community. The study recommends that there is need to enhance the integration of STEM education into Uganda's HIL by recruiting quality staff, increasing funding and strengthening collaboration and partnership between academia, industry and community. This will produce skilled graduates who are job creators and highly employable in industry, a requisite for sustainable economic growth in the 21st century.

Keywords: *STEM education; Higher education; Job creation; Industrialisation; Sustainable economic growth.*

Introduction

The integration of Science, Technology, Engineering and Mathematics (STEM) in academia, industry and the community has become a global priority in recent years, especially in highly competitive and developed countries, for example, in Europe, Asia and the United States (Lee & Lee, 2022; Rifandi & Rahmi, 2019; Marginson et al., 2013). This introduction briefly explores the multifaceted aspects of STEM education and its impact on various sectors in academia, industry and the community. It also highlights the significance of STEM in achieving the Sustainable Development Goals (SDGs) through skills development, job creation, industrialisation and fostering economic growth (United Nations, 2017).

The developing nations have also responded to this important UN call by aligning their National Development Plans (NDPs) in accordance with SDGs. For example, Uganda's Third National Development Plan (NDPIII) emphasises the importance of STEM education and its role in promoting industrial development and socio-economic transformation (Kagwa & Mugabi, 2017; Government of Uganda, 2020). By incorporating integrated STEM education initiatives into the national development plan, Uganda aims to prepare its citizens and the general community for the challenges of the future and enhance the nation's overall competitiveness on the global stage (Ecuru et al., 2011).

Furthermore, developing countries, including Uganda, recognise the importance of HE training and public-private partnerships (PPPs) in achieving SDG targets. Governments play a vital role in creating an enabling environment for STEM education by investing in education, research and innovation (Hodson, 2003). Public-private partnerships can bridge the gap between academia and industry, allowing for knowledge transfer and industry-relevant skill development. The establishment of STEM education-focused universities like Busitema University (BU) plays a pivotal role in promoting STEM education and research (Marginson et al., 2013).

Whereas there have been several attempts to bridge the wide gap between theoretical and practical skills development in HIL, integrated STEM education is considered to be key in eliminating the disparity between the skills possessed by graduates and the demands of industry. The major reason behind the mismatch in graduate skills is the fact that there is more emphasis on theoretical content delivery than on promoting integrated STEM education that advocates for practical skills. Thus, there is a need to reorganise curricula so that they align with market needs, practical exposure and real-world problem-solving (John, et al., 2018).

Furthermore, integrated STEM education offers practical exposure to real-world challenges and aligns with the needs of the job market. There is need to emphasise the importance of experiential learning, internships and industry-academia collaborations to bridge the gap between theoretical knowledge and practical skills (Ruhanen, 2006). To this effect, integrated STEM education in HIL would produce graduates that can significantly impact communities through job creation. By equipping graduates with STEM entrepreneurial skills, they gain opportunities for sustainable livelihoods and economic upliftment (McKinney et al., 2017).

Integrated STEM education is considered as a channel for enhancing graduates' employability by equipping them with in-demand skills and competencies. The need to explore the various approaches, such as career counselling, mentorship, industrial attachments, career guidance for HE, entrepreneurial skills development programmes, and professional certifications, so as to enhance graduates' prospects in the job market (Cranmer, 2006).

The quality of academic staff in integrated STEM education plays a pivotal role in shaping the overall learning experience and research output of students. There is a need to explore how the competence, expertise and dedication of academic staff impact the effectiveness of teaching methods, students' understanding of STEM education concepts, and the quality and quantity of research produced (Waugh, 2002). By investigating the correlation between the capabilities of academic staff and educational outcomes, this study sheds more light on the importance of investing in faculty development and continuous improvement to enhance the overall quality of STEM education.

The integrated STEM education in HIL is increasingly recognised as essential drivers of innovation, economic development and social progress (Sasson, 2019). However, the successful implementation of integrated STEM education initiatives relies on effective collaborations and synergies among academia, industry and community stakeholders. The concept of integrated STEM education in partnership with academia, industry and the community can be well understood in the following analytical framework.

Analytical Framework

The general analytical framework of integrated STEM education is represented in the schematic model in Figure 1 that helps in identifying the existing gaps by not looking at HE/HIL in isolation from the key stakeholders in industry and the community. This model provides a unified framework that integrates activities across these sectors. Figure 1 gives an outline of the various fields and the major skills that are produced under the different STEM fields. By fostering cooperation, knowledge and skills exchange, the model aims to promote a holistic approach to STEM development, which can lead to the creation of a skilled and competitive workforce capable of addressing real-world challenges.

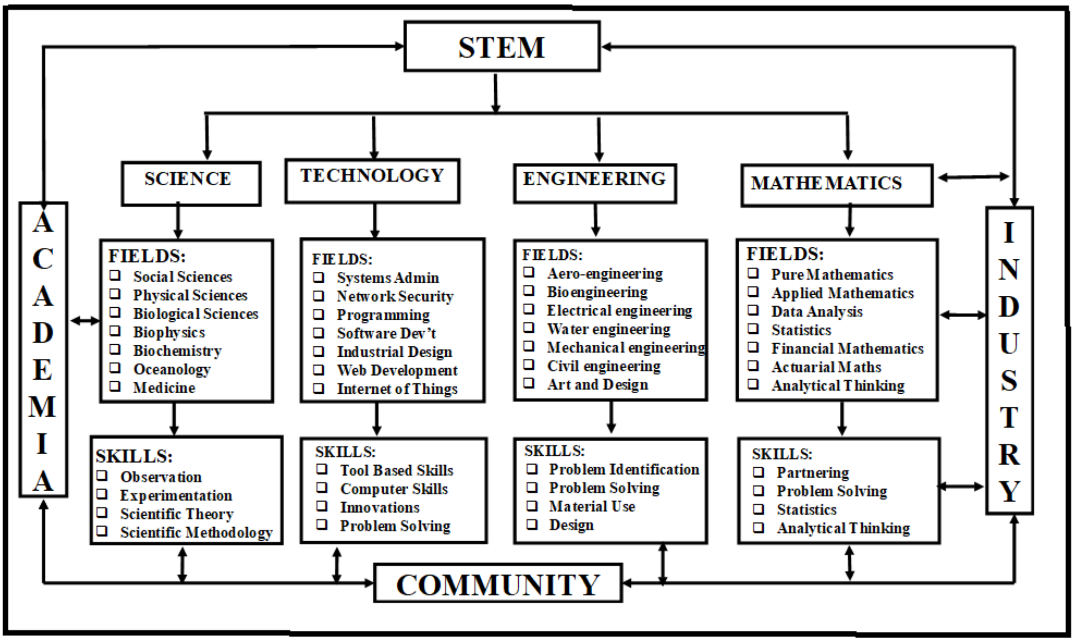

Figure 1. *The integrated STEM education schematic model*

The integrated STEM education schematic model is divided into several key components, each representing a distinct domain where integrated STEM activities can be implemented. The component of STEM education in academia focuses on the role of academic institutions, ranging from primary to university levels and technical institutions, in nurturing future innovators and problem-solvers. The major activities emphasised under STEM education in academia include enhancing the curriculum to integrate hands-on STEM activities, project-based learning, building teaching and research capacity, teacher training and entrepreneurship education in academic curricula to enhance students' practical skills.

The component of STEM education in industry underscores the importance of collaboration between academia and industry to translate research and knowledge into tangible applications and research commercialisation. The key activities emphasised under this component include fostering partnerships and collaborations between universities, research institutes and industries to promote technology transfer, joint research projects and internships for students. This can further be strengthened by establishing dedicated spaces to support start-ups and facilitate the commercialisation of research findings, fostering a culture of entrepreneurship within industries.

The component of STEM education in the community recognises the transformative power of STEM education and activities in empowering local communities, ordinary citizens, disadvantaged groups, unemployed graduates and entrepreneurs. Among many activities, it emphasises developing short-term courses that provide practical skills in areas like coding, digital literacy, robotics and the enhanced graduate skills need for manufacturing industry.

The above components can be enhanced by integrated STEM projects which should be designed to address the pressing issue of unemployment and skill gaps in the labour market. These projects are aimed at driving practical solutions and fostering unified collaboration between academia, industry and the community. The major integrating project activities include facilitation mentorship programmes, increased access to resources, and unlocking new opportunities by experts from academia, industry and the community with students, youth, graduates, women and disadvantaged groups to bridge the gap between theory and practice.

The integrated STEM education schematic model provides a comprehensive and cohesive framework that aims to integrate and promote STEM activities in academic, industrial and community settings. The successful implementation of the model relies on the commitment of stakeholders, the presence of qualified staff, and supportive policies that foster an environment conducive to STEM development. Through the integrated STEM projects and activities, the model seeks to address immediate challenges and contribute to the overall growth and development of the nation.

STEM education has been widely studied, embraced and fully implemented in developed countries (Lee & Lee, 2022, Marginson, et al., 2013). This is not, however, the case with developing nations like Uganda. The schematic model above emphasises the strong linkage between academia, industry and the community in fostering STEM education through collaboration, knowledge exchange, targeted support, skills development and producing innovative workforce capable of driving sustainable socio-economic growth and transformation. This study identifies the existing research gaps as lack of systematic description of STEM education practices, defined factors that can shape stakeholders' participation and problems that are faced in its implementation in Uganda.

Based on the above background, our study was guided by the following research questions (RQs):

RQ1. What are the effects of the quality of academic staff in HIL on teaching, learning, research and innovation output in integrated STEM education?

RQ2. What is the scale of practical teaching, learning, research and innovation efforts in terms of funding and time spent on research and innovation output in STEM education?

RQ3. What is the impact of academia, industry and community partnerships and collaborations on the perceived success of integrated STEM education?

By answering these research questions, we offered valuable insights into the factors that influence the quality and effectiveness of integrated STEM education in academia, industry and the community. The findings will provide evidence-based recommendations for enhancing the role of academic staff, optimising resource allocation, and fostering strong partnerships between academia, industry and community, ultimately contributing to the holistic growth and transformation of STEM education in Uganda.

Literature Review

The literature review was structured on the basis of the identified key components of the integrated STEM education analytical framework as discussed in the previous section.

Integrated STEM education has been fronted by many scholars as a catalyst for socio-economic growth and transformation of developing nations (Lee & Lee, 2022). The integrated approach to teaching and research in STEM education cultivates innovative skills and produces a proficient and skilled workforce to contribute to the creation of competitive industries (Ahmed, 2016). Developing nations need to increase their investment in integrated STEM education to be able to empower their citizens with relevant innovation and entrepreneurial skills to ensure sustainable economic growth in the 21st century (Rifandi & Rahmi, 2019).

For HIL to successfully integrate practical STEM education in HE, it is imperative to first establish the teachers' attitude and quality in relation to STEM teaching, research and innovation. These teachers are responsible for shaping students' STEM skills that are required in industry and general community development (Johnson, 2006). This calls for retooling the HE teachers and enhancing the teacher training programmes to reflect contemporary approaches to integrated STEM education (Tytler & Self, 2020). Many teachers in HIL have been trained through the traditional curricula that emphasised classroom-based and theoretical teaching, while other teachers are resisting the changeover to the contemporary approaches required for effective STEM teaching and research. It would be futile for integrated STEM subjects to be introduced in HIL in the absence of qualified staff and relevant curricula. Many STEM researchers have recommended the enhancement of knowledge, experiences, mentorships and background preparation for teachers to be adequately equipped to effectively impart integrated STEM education (Hill et al., 2020).

The HIL offering STEM education need to enhance the training procedure for the pre-service and in-service teachers so that they are better prepared and equipped with STEM practical skills before they are deployed in schools and HE institutions (Pimthong & Williams, 2018). These STEM subject instructors in HIL need to enhance their teaching and research skills so as to be innovative in introducing subject content that is well aligned with contemporary thinking regarding the subjects (Dailey et al., 2015). There is also a need to equip teachers with diverse, multidisciplinary knowledge and skills in the various STEM subjects and also for the teachers to learn how to work with other teachers in the same field. This also calls for the creation of professional development opportunities in integrated STEM education that will help teachers nurture students' critical thinking, innovation, collaboration, creative problem-solving and scientific communication skills. Such initiatives could further promote the use of innovative approaches to STEM teaching and research, the development of low-cost and affordable STEM teaching materials, as well as conducting STEM research in academia, industry and the community (Nakabugo et al., 2019; Nakayiwa & Tumuhairwe, 2021).

Reliable internet connectivity and updated ICT resources are vital in enhancing STEM teachers' interest and skills development. These resources still remain a big challenge in developing countries. Lack of these resources hinders the process of STEM teaching, research and innovation at all levels of academia. This same challenge also hinders teachers' exposure through collaborations and partnerships with other HIL. Thus, scientific research and technological capabilities play a fundamental role in STEM education (Skliarova et al., 2022; Khayyat & Lee, 2015). Many related studies have explored technological initiatives aimed at promoting research infrastructure and fostering a research culture in academic institutions to enhance STEM education research outputs (Wasswa & Kituyi, 2019; Muhumuza et al., 2022).

In the context of Uganda, the establishment of dedicated STEM universities, such as BU, signifies a commitment to promote STEM education and its impact on producing a skilled labour force. This goal is liable to fail at implementation level because of inadequate funding to provide both human and infrastructural resources that are important for motivating both staff and students to commit more time and effort to STEM research, innovation and skills development. There are several case studies, evaluations and research papers that examine the need for resources if the STEM universities have to be successful and able to make a contribution to the broader goals of the nation (Mugabi et al., 2020; Marginson et al. 2013; Kisubi et al., 2021).

Inadequate funding greatly contributes to the challenge of STEM education and the mismatch between the skills possessed by graduates and the demands of industry. Inadequate funding also leads to the production of half-baked graduates that cannot meet industrial needs. Many research studies have been conducted that cast more light on the causes and consequences of this disparity and the potential strategies for aligning STEM education with industry needs (John et al., 2018; Mugisa et al., 2017; Kyamugambi et al., 2019).

The current education system is characterised by a costly education whose main result is a large number of unemployed graduates. Despite the current efforts to emphasise a STEM education, high unemployment rates among STEM graduates remains a big concern. The major reason behind this phenomenon is inadequate funding to motivate STEM teachers and students to dedicate more effort and time to producing skills required for job creation and in industry. This has been analysed in recent research studies, and interventions aimed at addressing the issue and improving employment prospects for STEM graduates have been recommended (Langdon et al., 2011; Nansubuga & Walugembe, 2018; Nakabugo et al., 2021). Studies have also explored the factors contributing to graduate unemployment and proposed strategies to enhance graduates' employability through entrepreneurship and skills development (Osmani et al., 2015).

The significance of a robust STEM education in equipping graduates with all the necessary and in-demand skills to make them highly employable cannot be overemphasised. This crucial role of enhancing graduates' employability can only be achieved through adequate funding and exposure to varied experimentation both in industry and in the community. Such initiatives that have focused on improving graduates' prospects through career counselling, skills development programmes, and industry attachments have been fully explored by various scholars (Cranmer, 2006; Kiwanuka et al., 2019; Nansubuga et al., 2021; Wasswa et al., 2022;Walakira, F. E., & Semakula, D., 2021)).

The power of strong collaboration between academia, industry and community in accelerating the attainment of SDGs cannot be overemphasised. The United Nations has also recognised the pivotal role of STEM education in achieving the SDGs. Target 9.5 specifically highlights the need to enhance scientific research and technological capabilities, emphasising the role of STEM in driving innovation and sustainable industrialisation (United Nations, 2017; Ecuru et al., 2011). The achievement of Target 9.5 can further be accelerated by encouraging and funding STEM education in HIL as key tools to enhance innovation for skills development, job creation, industrial growth and community development. Researchers have explored how STEM education aligns with the broader goals of the SDGs and its potential to contribute to the Fourth Industrial Revolution (4IR/Industry 4.0), as well as social and economic development (El-Jardali et al., 2018; Nsamba et al., 2022; Namuddu & Kiyingi, 2019).

Methodology

Here are the details of the methodology, elaborating on the online survey and its design for each target group: academic staff, students, industrialists and community members. The survey was structured on the basis of a general theoretical model outlined in the model that outlines the linkage between academia, industry and the community and the expected STEM activities, respectively, as briefly discussed below.

To comprehensively investigate the integration of STEM in Uganda's higher education for job creation and sustainable economic growth, we employed a mixed-methods approach, with the primary data collection method being an online survey. This survey was designed to gather insights and opinions from various stakeholders in academia, industry and the community, who included academic staff, students, industrialists, and community leaders in education, government, non-governmental organisations (NGOs) and small and medium enterprises (SMEs). This aimed at understanding the perceptions, experiences and challenges associated with integrated STEM education and its impact on the various sectors.

The online survey was designed using an online user-friendly platform, Google Forms, to ensure ease of access and participation for respondents. The questions were a combination of multiple-choice, Likert scale and open-ended questions to gather both quantitative and qualitative data. To ensure the survey's validity and reliability, a pilot test was conducted with a small sample of participants before the full survey was launched. The survey link was distributed through various channels, including email invitations to academic staff and industrialists, notifications on educational platforms, and community-based organisations (CBOs) and SMEs for community members. The respondents' confidentiality and anonymity were assured, and informed consent was obtained before participants engaged in the survey. The data obtained from the survey was analysed using descriptive statistics, to derive meaningful insights. The results of the survey were then presented in the research findings section, after which the implications were discussed to inform the recommendations and conclusions of the study.

Results and Discussion

The chapter provides a discussion of the results related to the quality of STEM staff, funding for STEM research and innovation, and STEM partnerships and collaborations in academia, industry and the community.

Quality of STEM education in academia, industry and community

The first aspect we examined in this study was the quality of STEM staff in academia that mainly feeds a trained and skilled labour force into industry and the community. The study focused on assessing the qualifications, expertise and competence of lecturers involved in STEM education and the core duties of conducting practical teaching, research, innovation and outreach.

The research findings indicated that academia comprises men and women who are qualified to support STEM education at the university, of whom 66.7% are male while 33.3% are female. Of these respondents, 40.5% hold a doctorate, 23.8% a master's degree, 46.2% a bachelor's degree in education, and a small percentage – 9.5% – a certificate. A good percentage of the lecturers are at the rank of associate professor and professor, which provides a good ground for support in research and innovation. The results indicated that the staff have sufficient expertise to effectively deliver STEM education through conducting practical teaching, research, innovation and outreach to the general community and to industry, as can be seen in Figures 1(a)–(e). However, 72.1% (Figure 2a) raised concern regarding the need for continuous professional development programmes, which include refresher courses, workshops or conferences, observational and field visits to other institutions, mentoring or coaching, peer observation, qualification programmes, attending conferences or seminars, engagement in continuous research and outreach programmes so as to enhance the teaching and research skills of STEM staff. One can refer to the results indicated in Figures 1(a)–(e) and Figures 2(a)–(f) for responses on the STEM education staff demographic information of STEM and STEM education courses, programmes, teaching, research and innovation, respectively.

In the industrial sector, the results suggest a mixed perception of the quality of STEM education. While 51.2% of the respondents expressed satisfaction with the expertise and qualifications of industry professionals, 32.6% identified skill gaps and a need for upskilling programmes to align with the rapidly evolving technological landscape. The findings further emphasise the importance of industry-academia partnerships to bridge these gaps and ensure that the skills of STEM staff in industry are up-to-date and relevant.

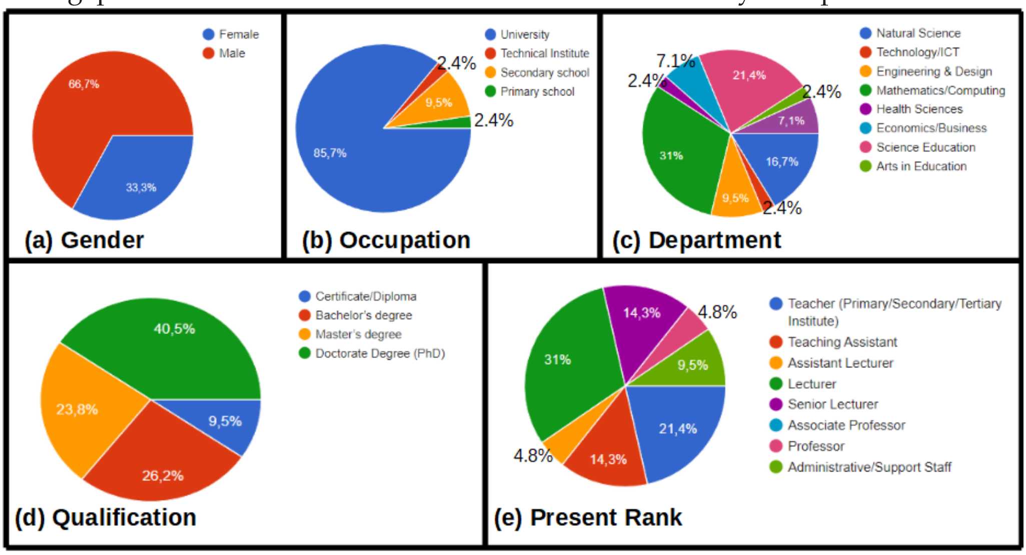

Figure 1(a)-(3), show responses on staff demographic information and qualification

In connection with the community, the research findings indicate a need for enhancing the quality of STEM staff. The participants highlighted the importance of providing training and capacity-building programmes for individuals working in community-based STEM initiatives. The results also emphasise the significance of mentorship and knowledge transfer programmes to empower community members with the necessary skills and expertise to actively engage in STEM activities.

Funding STEM research and innovation

The second aspect explored in this study is the availability and adequacy of funding in terms of resources to support STEM education with regard to teaching, research and innovation. This involved examining the financial resources allocated to support research projects, the availability of grants and scholarships, and the overall investment in STEM-related activities, including practical teaching, experimentation, research, innovation, entrepreneurial skills development and outreach activities. The research findings revealed that STEM programmes exist in universities as indicated in Figure 2(a), where 72.1% of the respondents agreed with the argument. This level of existence is through integrated teaching and learning of some STEM courses at undergraduate level, as can be seen in Figures 2(d) and 2(e).

In addition, the participants expressed concerns about the limited grant and financial opportunities available to support STEM projects, which hinders the advancement of scientific knowledge and the development of innovative solutions, as indicated in Figure 3(c). Only a small percentage – 34.9%– agreed that grant opportunities were available. Related to this fact, 60.5% (Figure 3(c)) of the respondents expressed concern about lack of sponsorship for students in STEM-related fields. The study thus identified this as a setback to research and innovation in universities since potential STEM students may not have an opportunity to engage in STEM-related research and innovation owing to lack of support.

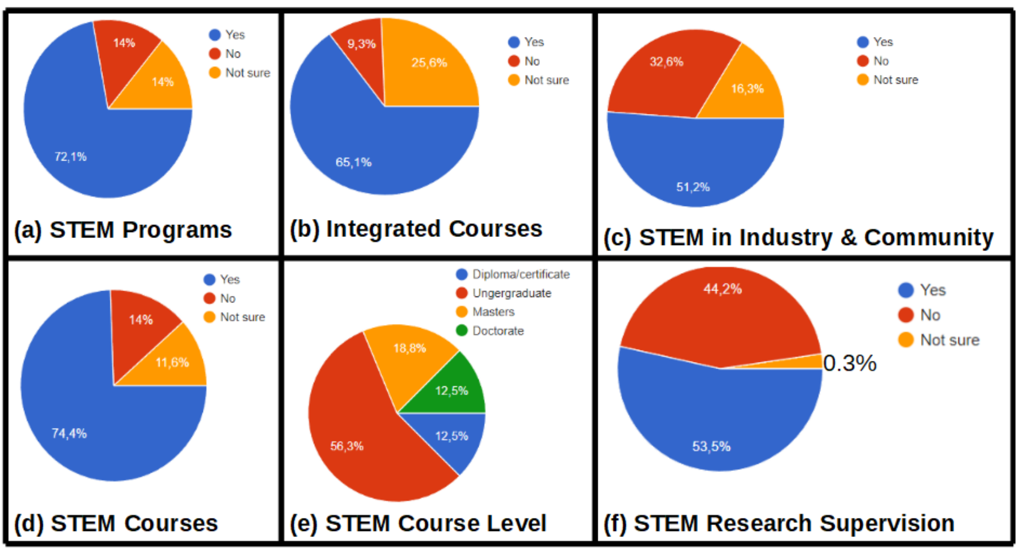

Figure 2(a)-(f), show responses on STEM teaching, research and innovation

The study also reveals that, on average, 34.9% of the respondents, as indicated in Figure 3(d), justified the need for strengthening higher education policies to promote STEM education. In addition, an average of 44.7% of the respondents, as indicated in Figure 3(e), justified the need for increasing the infrastructural resources, including laboratory space, lecture space, laboratory equipment, ICT infrastructure, library resources, internet resources and stable power supply, which are needed for a robust integrated STEM education. On the whole, the study emphasised the need for increased investment in STEM teaching, research and innovation. This includes advocating for increased government funding, encouraging private sector partnerships, attracting grants and sponsorship opportunities, and strengthening collaborations between academia, industry and the general community to secure additional financial resources. The findings underscore the crucial role of adequate funding in promoting scientific discoveries, technological advancements and sustainable development.

The study further revealed that the academic staff are not given adequate time for field trips and outreach activities. Table 1 shows that only 26.2% (percentage of high and very high) of the respondents agreed that the staff were allowed time for field trips, while 45.3% (low and fair) expressed disagreement. There is need to create more opportunities for the effective use of consultation time as justified by a small percentage of 33.3% (at high and very high levels of satisfaction). There is great need to make available refresher courses, consultations and relevant training in STEM, as well as effective use of consultation time and funding. The competency-based curriculum (CBC) in lower secondary schools is an indication of the shift away from the traditional knowledge-based curriculum (KBC) that had dominated Uganda's education system right from primary up to university level (Wambi et al., 2024).

STEM partnerships and collaborations in academia, industry and community

The third aspect examined in this study was the extent and effectiveness of STEM partnerships and collaborations among academia, industry and the community. This includes assessing the level of cooperation, knowledge exchange, and joint initiatives between these sectors.

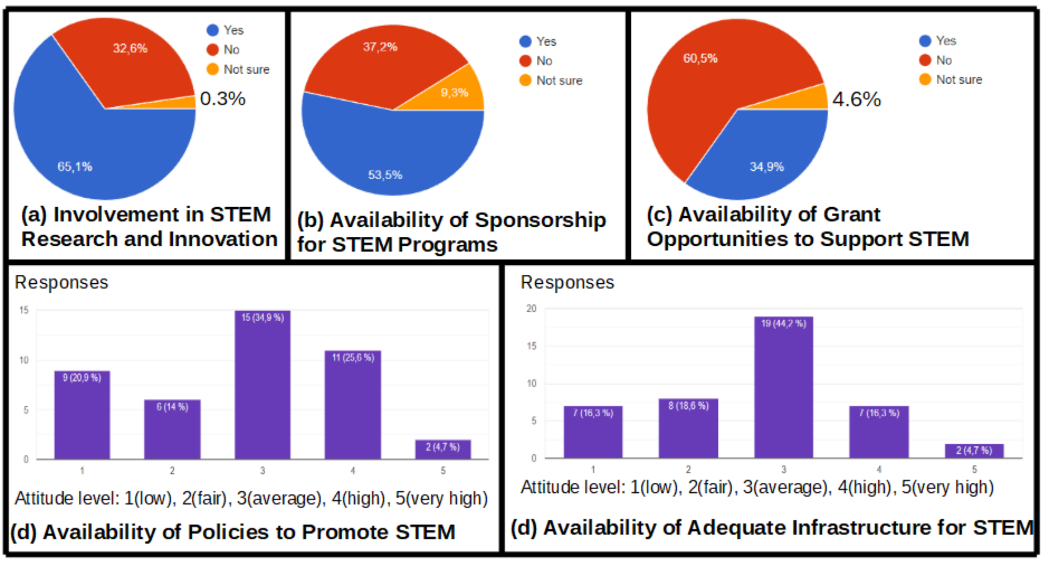

Figure 3(a)-(d), show responses on STEM policies, sponsorship, and infrastructure

The research findings suggest that while some collaborations and partnerships exist, there is still need for improvement in fostering effective STEM collaborations. Table 2 reveals that 38.1% of the participants identified the need for building a culture of collaboration and partnership for higher-level connections and increased communication between academia, industry and the community to leverage expertise, resources and opportunities. The findings highlight the potential benefits of collaborative efforts, such as technology transfer, joint research projects, internships and knowledge-sharing.

Table 1. *Responses on funding STEM research and innovation*

Responses	Level of Satisfaction and Number (or Percentage) of Respondents				
	Low	Fair	Average	High	Very high
Availability of time for field trips	12 (28.6%)	7 (16.7%)	12 (28.6%)	9 (21.4%)	2 (4.8%)
Provision of adequate funds	11 (26.2%)	1 (2.4%)	16 (38.1%)	11 (26.2%)	3 (7.1%)
Effective use of consultation time and funds	11 (26.2)	12 (28.6%)	14 (33.3%)	4 (9.5%)	1 (2.4%)
Availability of refresher courses in STEM	7 (16.7%)	12 (28.6%)	11 (26.2%)	9 (21.4%)	1 (2.4%)

The study further shows that only 88.4% (fair + average+ high+ very high) of the participants see the importance of enhanced staff development in partnerships and collaborations to enhance the impact of STEM activities. This would include establishing formal channels for communication, promoting knowledge exchange platforms, and facilitating joint initiatives that address real-world challenges. The findings underscore the value of collaborative efforts in driving innovation, improving the relevance of STEM education and research, and maximising the socio-economic impact of STEM initiatives.

Overall, the results and discussion highlight the significance of addressing the quality of STEM staff, securing adequate funding for research and innovation, and fostering effective partnerships and collaborations in academia, industry and the community. These findings provide valuable insights for policymakers, educational institutions, industry leaders and community stakeholders to enhance the success and impact of STEM initiatives and contribute to sustainable socio-economic development.

Table 2. *Partnerships and collaboration in academia, industry and community*

Responses	Level of Satisfaction and Number (or Percentage) of Respondents				
	Low	Fair	Average	High	Very high
Building a culture of collaboration and partnership	5 (11.5%)	10 (23.8%)	10 (23.8)	16 (38.1%)	1 (2.4%)
Availability of funds to enhance collaboration	8 (19.0%)	11 (26.2%)	15 (37.5%)	6 (14.3%)	2 (4.8%)
Enhanced staff development in partnership	5 (11.2%)	12 (28.8%)	13 (31%)	10 (23.8%)	2 (4.8%)
Availability of modes of staff research and exchange	8 (19.0%)	12 (28.6)	10 (23.8)	10 (23.8%)	2 (4.8%)

Conclusion and Recommendations

Conclusion

In this study we explored the integration of STEM education in HIL (or HE) in partnership with general academia, industry and the community to promote job creation, industrialisation and sustainable economic growth in Uganda in the 21st century. The research findings highlight several critical factors influencing the success of integrated STEM education initiatives and their impact on national development. Through a comprehensive analysis of STEM in different contexts, the study has identified areas that require attention and strategic interventions.

The study discovered that while academia generally has qualified staff to support integrated STEM education in terms of teaching, research and innovation, there is still a wide gap between HE, industry and various sectors in the community. This is mainly attributed to the challenges in finding highly skilled STEM education professionals and experts, the greater emphasis on theoretical content than on practical teaching and a general lack of financial and/or infrastructural resources to support integrated STEM activities. Thus, there is a need for continuous professional development for academic staff through mentorship programmes, refresher courses and adequate facilitation for workshops and conferences so as to produce professionals who can enhance the quality of STEM education across all sectors in academia, industry and the community.

The study revealed limited funding for integrated STEM education in terms of supporting teaching, research and innovation in HIL in partnership with industry and the community. The general limited infrastructure and human resource to support STEM education hampers technological advancements, industrialisation and socio-economic development through the production of the skilled labour force required in the 21st century. Thus, governments, private corporations and development partners should collaborate to increase investment in integrated STEM education at all levels of academia, industry and the community.

The study further revealed that the level of integrated STEM education partnerships and collaborations between academia, industry and the community is currently at its lowest. Strengthening partnerships between the HIL, industry and community stakeholders can lead to an increase in resources and drive a high level of teaching, research, innovation, skills development, knowledge exchange and other competences which is required by the labour force to support socio-economic transformation.

Therefore, embracing STEM in academia, industry and the community holds the key to unleashing Uganda's potential for job creation, industrialisation and sustainable economic growth. By implementing the recommended strategies and collaborating across sectors, stakeholders can pave the way for a brighter future driven by innovation, knowledge and skills.

Recommendations

Based on the research findings, the study puts forth the following recommendations to enhance the integration of STEM in Uganda's education for job creation and sustainable economic growth:

1. The government should increase investment in HIL to support STEM education. This should include investing more human, material and technological resources that can favour the incorporation of practical STEM activities, project-based learning, entrepreneurship skills development and enhanced partnerships with other institutions.
2. The government should make funds available to facilitate and strengthen partnerships between academic institutions, industry and various sectors in the community that key players in fostering technology transfer, joint research projects, industrial and field attachments, internships and general exposure to modern STEM resources. Comprehensive assessments of both industry and community needs can help align STEM education and research problem formulation with the general market and societal demands.
3. The government should attract more development partners to create and make available more dedicated funding opportunities for integrated STEM education in terms of practical teaching, research, innovation and entrepreneurial skills development in the academic, industrial and community sectors. In line with Kaweesi et al.'s (2019) view, this can be achieved through encouraging healthy donor-recipient working relationships, providing grants to promote research and innovation, public-private partnerships, and establishing venture capital initiatives.
4. HIL as well as stakeholders in industry and community should establish mentorship programmes that connect experienced STEM professionals with youth, graduates, women, unemployed graduates and other interest groups. This can help bridge the skills gap and empower individuals to engage in innovation and entrepreneurship.

In order to further strengthen the integration of STEM education in academia, industry and the community in terms of teaching, research and innovation at all levels, the study suggests the following recommendations:

1. **Increase the number of technology hubs and maker spaces:** An increased number of community-based technology hubs and maker spaces should be established to provide access to STEM resources, tools and training for local communities and entrepreneurs.
2. **Enhance vocational training programmes:** Develop enhanced short-term vocational training courses that provide practical STEM skills, especially in areas like coding, digital literacy, robotics and advanced manufacturing.
3. **Promote gender diversity in STEM:** Encourage women's participation in STEM fields through scholarships, mentorship and networking opportunities. A diverse STEM workforce can drive innovation and creativity.
4. **Organise STEM innovation competitions:** Organise innovation challenges and entrepreneurship competitions to encourage youth to develop impactful solutions for local challenges. This can nurture a culture of innovation and problem-solving.
5. **Enhance curriculum development:** Continuously improve STEM curricula and programmes to ensure they align with market needs and equip graduates with relevant skills.
6. **Facilitate networking and workshops:** Organise networking events and workshops that bring together youth, graduates and women with industry experts to explore career opportunities and knowledge-sharing.

Future Research

While this study provides valuable insights into integrated STEM education for job creation and economic growth in Uganda, owing to the limited time frame in which this study was conducted, in future we plan to conduct a comparative analysis of integrated STEM education efforts across countries to identify best practices and lessons learnt. This longitudinal study will, among others:

a) Track the impact of integrated STEM education on job creation and economic growth based on countries where such initiatives have been successfully implemented over an extended period so as to provide more comprehensive insights.

b) Assess the effectiveness of existing integrated STEM education policies in countries where the same have been successfully implemented and accordingly recommend strategies for enhancing policy implementation.

c) Investigate the role of digital technology in promoting integrated STEM education in terms of teaching, research and innovation based on identified countries where great success has been registered.

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