The DSAIL-GeJuSTA Data Science Education Workshop: Designing a Data Science Curriculum for the African Continent

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Abstract

The DSAIL-GeJuSTA Data Science Education Workshop was a joint initiative by the Centre for Data Science and Artificial Intelligence (DSAIL) and Gender Justice in STEM Research in Africa (GeJUSTA). GeJUSTA is a programme funded by the International Development Research Centre (IDRC) that is working towards increasing the representation of women in STEM. The workshop was held on 9 November 2023, during the 7th DeKUT International Conference on Science, Technology, Innovation and Entrepreneurship (STI&E) at Dedan Kimathi University of Technology (DeKUT). The conference ran from 8-10 November 2023. The event successfully convened 31 participants. The composition of the attendees was diverse, ranging from data-science educators, industry participants using data science, researchers who use data science and students in a myriad of courses, including engineering and pharmacy. The primary focus of the workshop was to have a discussion with the attendees and share practices around designing data-science curriculum, strategies for achieving gender equity in data-science education, addressing new technological challenges in education and fostering multidisciplinary approaches to data-science education. This report encapsulates the collective vision of the workshop participants, whose contributions have set the stage for progressive strides in data-science education.

Keywords

curriculum, data science, education, gender

Date and place

This workshop was conducted on 9 November 2023, at Dedan Kimathi University of Technology, Nyeri, Kenya.

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Introduction

Data science, artificial intelligence and machine learning are emerging technologies that have been responsible for several important technological advances. The pace at which these fields are changing has made it difficult for traditional approaches to teaching, such as university programmes, to keep up. There are important questions about how these subjects should be taught and to whom they should be addressed.

In Africa and beyond, the potential of data science and AI is immense and it is important to make these skills accessible to a critical mass of practitioners. Universities need to play their role to ensure adequate human resource development. Despite the increasing interest in data science and AI, considerable challenges such as fairness, accountability, ethics and explainability lie ahead. Future data scientists will not only need technical knowledge, but also a deeper, more critical appreciation of these challenges and how they can potentially address or perpetuate inequities in societies. In data-science education, therefore, it is critical to share existing practices and learn from practitioners how data-science curricula are embedding technical as well as social perspectives.

Background

The under-representation of women in science, technology, engineering, and mathematics (STEM) is a persistent issue. Studies have shown that women account for less than a third of those employed in scientific research and development (World Economic Forum 2020, Anthony Martinez 2021, Martinez and Christnacht 2021, Tamrat 2023). They are also significantly under-represented in engineering and computer science programmes.

Globally, challenges that have led to the under-representation of the female gender in STEM can be classified under several key titles. The main one is the negative impact of gendered social norms on young women (Wang and Degol 2016) with ideas such as “there are jobs for men and jobs for women" (Luvanda 2023). Therefore, many young women are discouraged from enrolling in STEM majors or starting careers in STEM since these courses are regarded as masculine courses, which is why they attract a lot of men. Young women are also discouraged from choosing and sticking with careers in STEM since careers in STEM are regarded as not being family-friendly (Reinking and Martin 2018). According to studies focused on discovering the main causes of girl-exclusion from digital technology education at all levels in Kenya, it was discovered that very few women from the focus groups created at the secondary school level of education were inclined to pursue careers in engineering, science and even digital technology (Luvanda 2023). This result was mostly credited to the negative impact of gendered social norms, amongst other reasons. Another reason is the lack of awareness amongst young women of the career opportunities available in STEM. According to the study at Brookings (Luvanda 2023), most girls in the focus groups at the lower primary, upper primary and junior high school levels did not have an idea of there being opportunities for them to

excel in STEM. Additionally, most of the young women in these categories did not know what a career in STEM entails. Similarly, a considerable number of girls at the university level who were not pursuing STEM courses did not clearly understand STEM careers (Luvanda 2023). Only a few young women in STEM courses had an understanding of what comprises careers in STEM.

Lack of female mentorship in STEM from a young age is also another critical title. When young children (girls and boys) are growing up and they are at their low but critical levels of education, most of their role models are people close to them, for example, their parents or teachers (Cherednichenko 2014). The pool of role models expands when they get to high schools, where they have the opportunity to interact with books and people from different backgrounds. At this level, a well-known individual such as Bill Gates might be suggested as a role model. This shows that the children have a better understanding of the world around them. Despite having role models, when young men and women narrow down to one field of study at the university level, studies show that they more importantly require mentors over role models. At this level, a mentor is someone who has excelled in a particular field of study and is willing to guide the young minds through (Rice and Alfred 2014). Therefore, increasing the visibility of female role models who have excelled in STEM is an important step in attracting girls to STEM fields (Rice and Alfred 2014). However, this is often challenging due to the scarcity or even absence of female mentors in some STEM disciplines, underscoring the need for targeted efforts to support and promote women in these areas.

Another critical issue related to the lack of mentorship in STEM is the poor championing for STEM careers amongst women (Rice and Alfred 2014). According to Gabriel Tarde's book "In the Laws of Imitation," he suggests that imitation is a key component in the development of language and the evolution of institutions (Tarde 2024). Therefore, having female academic mentors who are willing to mentor young women in STEM will attract more young women, because they will have someone or something to identify with.

Lack of adequate career counselling is another hinderance. There is inadequate career counselling at the upper primary and secondary school levels in many developing countries (Luvanda 2023). Despite there being career counselling sessions and career offices in many tertiary education institutions, many students in different STEM courses are not decided about their career paths (Rudin 2017). In addition, since STEM courses attract a certain level of competitiveness, many young women who are inclined to pursue STEM courses are denied chances and, thereby, end up in courses they are not interested in (Luvanda 2023).

After highlighting the challenges, we point out the policies that have been introduced to address gender inequality in STEM. One of the policies is the introduction of programmes dedicated to getting women into STEM careers at the university level and also to get young women in the primary and high school level acquainted with what STEM is all about (Wang and Degol 2016). The programmes are meant to fill out the gaping STEM advocacy gap amongst women. In Kenya and other parts of the globe, women in STEM

are holding conferences, hackathons and retreats in a bid to get young women interested in STEM careers (Brenøe and Zölitz 2020). The conferences and hackathons breed foundations and organisations that are a source of inspiration, resources and mentorship for young women who are interested in STEM. Foundations such as the Scientista Foundation are helping to address the gender gap in STEM. It was founded in the USA by two sisters who recognised the lack of mentorship, resources and community for women in science. Scientista launched a platform, Scientista.com, which is a resourceful site for female students and scholars in science and technology. Since its launch, over 30 campuses in the USA have joined the network and large organisations such as Microsoft have partnered with Scientista. Other programmes around the world include: Mind the Gap project, Girls Who Code, Million Women Mentors, American Association of University Women and the Anita Borg Institute, to mention a few.

In Kenya, there are programmes that have been rolled out to champion STEM, but are not gender-specific. Some of the programmes are the School Laptop Program, which did not take off due to the poor roll-out plan that was made worse by the overwhelming infrastructural and financial challenges (Wambugu 2019). Another programme that did not do well was the Digital Literacy Program, which was focused on introducing digital gadgets to primary school teachers and pupils (Amolloh et al. 2017). Although the programme was not curated for a specific gender, it was meant to expand the understanding of technology at the primary school levels. Another programme that was introduced recently is the Coding in School initiative, which was integrated into the new competency-based curriculum (CBC) (Kirwa 2023). Experts raised concerns about the initiative because there are other issues, such as lack of the needed infrastructure and computer illiteracy, that have to be addressed for the programme to be a success.

Another policy closely related to the launch of programmes is the establishment of organisations (which might be a result of the programmes) whose mode of operation is based solely on helping women excel in STEM by providing resources and career advice. One of the most important resources for getting women into STEM is financial aid, which includes scholarships and grant opportunities (Anyango 2024). Nowadays, most courses in STEM are expensive; hence, financial aid can go a long way in funding the studies of young women. In a bid to achieve gender balance in the opportunities offered, many organisations that offer scholarships to students have slots set aside for women (Maryville University 2020). Additionally, various universities have admission slots set aside for women who have qualified for various STEM courses. In job advertisements nowadays, STEM-based companies explicitly include a note of application for female applicants, which is meant to create interest in women who may want to make an application.

This concern about gender differences and the inclusion of effective curriculum design as a solution to the problem is a topic of significant discussion in the study of educational systems. Previous research indicates that the conventional curriculum promotes gender stereotyping and bias by granting limited chances and representation for females in STEM (Legewie and DiPrete 2009, Maryville University 2019). In response to this, scholars suggest that there is a need for a gender-sensitive curriculum that will provide

perspective and pose an alternative to stereotyping. Such a curriculum should offer students equal chances regardless of gender, promote mutual respect and tolerance and ensure that students develop a desire to pursue STEM courses right from a tender age.

Within the broader landscape of efforts to promote gender inclusivity in STEM, curriculum design emerges as a critical lever for change. In the present work, the influence of curriculum development on gender parity in STEM fields has been investigated in several works. Studies show that the use of multiple role models, realism, real-life accounts and practical approaches can be used to improve female student interest and performance in science, technology, engineering and mathematics lessons. Additionally, the cultivation of a growth mindset and opportunities for mentorship have been seen to help increase the self-confidence and interest of girl students in STEM careers. As well, some research also points to limitations, including a lack of support from teachers and a lack of adequate support, training and professional development that teachers may need in order to effectively incorporate gender-sensitive curricula into classrooms (UNESCO International Bureau of Education 2017).

To enhance future curriculum development in STEM education, the following guidelines are suggested by the researchers for pursuing gender inclusiveness (Pinnell et al. 2013, Liben and Coyle 2014, Reinking and Martin 2018, Walker et al. 2018, Roxanne Hughes 2020). Some of them include the use of gender-sensitive language and diversity, linking STEM content to issues affecting society, encouraging teamwork, offering role models and access to STEM learning from an early age; cultivating a positive attitude towards STEM learning; integrating gender-sensitive content; making available professional development to teachers; and involving girls in STEM-related co-curricular activities. The integration of these components will, therefore, enable educators to provide appropriate assistance to eliminate barriers that may hinder the success of all students in STEM careers.

Overall, the research on purposefully implementing gendered curricula in STEM reveals the importance of purposeful and informed implementations. Although considerable advances have been made in the efforts aimed at understanding best practices in teaching and promotion of gender equity, much remains to be done in terms of continued research and collaboration amongst educators, policy-makers and researchers to ensure that students of both genders have equal chances in STEM courses and professions.

Bridging the gender gap is imperative for creating an inclusive data-science education curriculum and ensuring that the curriculum reflects both technical and social considerations. By sharing best practices and learning from experienced practitioners, we can develop data-science curricula that not only impart essential skills, but also advance gender equality and social justice (Helman et al. 2020, Hammond et al. 2020).

Babirye et al. (Babirye et al. 2022) detail the collaborative process of developing a research agenda focused on data-science training and gender equality in Africa. This agenda was co-developed through peer learning and knowledge sharing, leading to a literature review that examined African scholarships in the data-science training

landscape. The paper also discusses the barriers for women in ICT and data science, such as sociocultural beliefs, gender stereotypes, workplace bias and family responsibilities. Additionally, it highlights the importance of pedagogical approaches like tutorials, fieldwork, hackathons and innovation challenges and their impact on empowering women through data-science training.

Despite the significant challenges highlighted, including the under-representation of women in STEM due to gendered social norms, lack of awareness, insufficient mentorship, inadequate career counselling and the mixed success of various STEM programmes in Kenya, there are substantial opportunities to address these issues through targeted educational initiatives. Various policies and programmes have been introduced globally and locally to bridge the gender gap in STEM, such as conferences, hackathons, mentorship programmes and financial aid opportunities aimed at inspiring and supporting young women. Additionally, the importance of curriculum design in promoting gender inclusivity cannot be overstated. A gender-sensitive curriculum that offers equal opportunities, promotes mutual respect and integrates real-life accounts and practical approaches can significantly enhance female students' interest and performance in STEM.

In response to these challenges and opportunities, the DSAIL-GeJuSTA Data Science Education Workshop was convened. These collaborative efforts are crucial in developing a data-science curriculum that is not only globally competitive, but also tailored to the unique needs of the African continent.

Aims of the workshop

The workshop brought together academics from various disciplines related to data science and industry representatives to discuss issues related to the data-science curriculum. In particular, we sought to discuss:

1. Design of data-science curriculum;
2. Achieving gender equity in data-science programmes;
3. Emerging technological issues in data-science education;
4. Multidisciplinary data-science education.

Key outcomes and discussions

The workshop started with introductory remarks from Prof. Ciira wa Maina, the Director of the Centre for Data Science and Artificial Intelligence (DSAIL) and also an Associate Professor at DeKUT in the Department of Electrical and Electronic Engineering. He made some opening remarks, invited all speakers and attendees and provided an outline of the goals we were hoping to achieve at the end of the workshop. Prof. Maina also started our presentations by introducing GeJuSTA, DSAIL and Data Science Africa (DSA), a grassroots capacity building organisation that conducts yearly summer schools and

workshops aimed at teaching the fundamentals of data science, artificial intelligence and other emerging technologies and promoting the application of these technologies to real-world applications in Africa.

Next, we had members of DSAIL, Gabriel Kiarie and Lorna Mugambi, talk to the participants about preliminary results from a study the lab conducted on gender representation analysis in STEM in African universities (Fig. 1). The research involved collecting and analysing data on faculty members from the nursing, computer science and information technology, engineering and biology departments. This was accomplished by mining information from the university websites. It also included a gender analysis of the authors of scholarly articles from 30 African universities. Overall, the representation of women in these fields was lower than that of men, with the exception of the nursing department in most universities. They also presented a pilot curriculum intervention implemented at the university in the form of a two-day workshop, dubbed the 'DSAIL Tech4Wildife workshop', on the use of artificial intelligence in aiding wildlife conservation efforts.

During the 'DSAIL Tech4Wildife workshop', 14 male students and 13 female students participated on day one, while 15 male students and seven female students participated on day two. Women's interest and participation in the workshop tutorials were lower than men's. However, it is noteworthy that the women who did express interest in attending the workshop were committed. They not only showed up, but also actively participated in both the theoretical and practical sessions. Gender distribution varied across different schools and courses. For example, on both days of the workshop, only female students from the Institute of Geomatics, GIS and Remote Sensing participated. The highest participation was from the School of Engineering with 24 students and the School of Computer Science and IT with 13 students (Fig. 2). The tutorial material was made available on DSAIL's website (Centre for Data Science and Artificial Intelligence 2023).

The next presentation was from Dr. Lawrence Nderu, a lecturer and research fellow at the Department of Computing at Jomo Kenyatta University of Agriculture and Technology (JKUAT). He is also an instructor at the JENGA School of Data Science and AI in Kenya. His presentation, "Navigating the Landscape of Data Science Education in Kenyan Universities: Addressing Emerging Technological Challenges and Industry Relevance", underscored that the incorporation of data-science programmes into Kenya's higher education is a recent development (Fig. 3). He stressed the importance of ensuring the curriculum is both industrially relevant and technologically up-to-date. The necessity of incorporating data engineering into the curriculum was highlighted to reflect the local industry's maturity and global trends, prepare graduates for the job market and enable them to contribute significantly to the nation's industrial progress.

Mr. John Matogo, IBM's CSR leader for Africa and the Middle East, made a presentation entitled "The Contribution of Industry to the Data Science Curriculum". He provided participants with an in-depth overview of IBM SkillsBuild, a free digital learning programme that assists people in developing skills and gaining access to career

opportunities in AI, data analytics, software engineering, cloud computing and soft skills (Fig. 4).

Following a brief interlude, the session gathered momentum once again. The attendees directed their attention to Dr. Moses Thiga, who brought his expertise as a senior lecturer in information technology from Kabarak University to the discussion. His perspective was particularly interesting given that they have been working on developing a data-science curriculum at their university. He reflected on the process of developing the curriculum, obtaining approval and dealing with the challenges that came with it. We also heard from Dr. Victoria Njoroge, a lecturer at the University of Embu. Her department is also looking into developing a data-science curriculum and she discussed their thought-process in doing so (Fig. 5).

Following the presentations, there was a plenary session in which all attendees were invited to reflect on the day's main topic, a data-science curriculum for Africa. The following issues were specifically addressed:

- Ideal content to meet industry and research needs;
- Rigour and relevance;
- Gender representation amongst students and faculty.

The workshop participants from a variety of stakeholders also contributed to a jamboard, where they provided feedback on some of the questions posed. Participants' input, recorded on sticky notes, provided valuable perspectives on the roles of various entities and the design of an effective data-science curriculum. The following summarises the discussions of the participants:

Stakeholder Roles: In developing a data-science curriculum, it is important to develop a shared understanding of who the primary stakeholders are and what their roles entail:

1. Students are expected to actively participate in and provide feedback on their learning experiences because they are recognised as the primary beneficiaries of the educational process.
2. Teachers are in charge of developing and delivering a curriculum that meets the changing needs of students (and markets).
3. Industry experts are called upon to provide real-world experience to students through internships and mentorship, enriching their academic journey.
4. Higher education institutions are responsible for providing the necessary educational tools and research opportunities to foster the discipline of data science.
5. Government agencies must provide appropriate funding and policy to support educational and research activities in data science.

Considerations for the curriculum: The workshop participants highlighted several key considerations for developing an effective curriculum:

1. Stakeholder engagement: The participants emphasised the critical need to engage a broad spectrum of stakeholders in shaping the curriculum, ensuring that it reflects a multitude of perspectives and expertise.
2. Industry relevance: To ensure comprehensive education, the curriculum must be applicable and pertinent to various industries, such as health, finance, telecommunications and media.
3. Alignment with Industry Demands: The workshop emphasised the significance of aligning educational content with the evolving industry requirements and future directions in order to develop a workforce that is both knowledgeable and adaptable.

Educational Objectives: The participants discussed the range of skills that are necessary for the students to develop through the data-science curriculum:

1. Skills Development: Emphasised the importance of providing students with a comprehensive skill-set that includes both technical and interpersonal abilities.
2. Analytical Skills: Emphasis was placed on the importance of teaching students how to effectively analyse and evaluate data models.

Curriculum Framework: The participants also discussed the range of skills necessary for the students to develop through the data-science curriculum:

1. Essential Subjects: advocated for a curriculum that integrates mathematics, statistics and computing, with a special emphasis on emerging fields such as artificial intelligence.
2. Mastery of Skill: Emphasised the importance of proficiency in visualisation tools and data-mining techniques as essential for a data-science programme.

Following a lunch break, Dr. Winfred Mutuku, a mathematics and actuarial science senior lecturer at Kenyatta University, led a round table discussion on structural barriers faced by women in STEM (Fig. 6). Several women in STEM who had attended the workshop also made valuable contributions, describing some of the difficulties they had encountered in their careers, whether in academic research or in the field. The challenges experienced were diverse. For example,

1. Unconscious bias from educators, family and colleagues.
2. Lack of financial support structures.
3. Culture dictates social roles for women that add responsibilities to women compared to their male counterparts.
4. Stereotypical ideas that sciences fit the male better.
5. Making difficult decisions on either starting families early or continuing with career progression.
6. Inappropriate remarks were made regarding mentor-mentee relationships between male mentors and female students.

Building on the foundation established in previous discussions, the focus shifted to addressing the challenges women face in STEM education. The next round-table session aimed to explore potential solutions. This session was moderated by three distinguished academics: Dr. Edna Too of Chuka University, Dr. Edward Ombui of Africa Nazarene University and Dr. Irene Nandutu of the University of Cape Town. The moderators aided the discussion on how educators and instructors can attract and retain women in STEM. Some of the points raised included:

1. Introducing data science to learners at an early age, even at the primary level;
2. Intentional mentoring and coaching;
3. Attempting to change the attitudes of all stakeholders, such as students, teachers, parents and the community;
4. Encouraging young girls to get involved in mathematics beginning in primary school;
5. Creating awareness and motivation early in the learners' lives;
6. Being focused in providing learners with support for their studies and research.

Conclusion

Drawing from the discussions and talks throughout the day, the workshop emphasised the collaborative effort and commitment needed to create a robust data-science curriculum that meets the diverse needs of its stakeholders. The curriculum must be dynamic, integrating both theoretical foundations and practical applications to equip students with the necessary skills to thrive in the data-driven industry. Industry partnerships are essential to ensure the curriculum remains relevant and aligned with evolving job market demands. The role of government in policy-making and incentives is critical to creating an environment conducive to learning and innovation. The ultimate goal is to develop a workforce capable of data analysis, model building and the application of machine learning and artificial intelligence to address future challenges. It is also crucial to acknowledge the need for gender equity in data-science education, ensuring that the curriculum supports the representation and success of women in the field. While the workshop effectively covered a range of educational objectives for the data-science curriculum, it did not delve into critical skills like ethics and fairness. These are vital components of a comprehensive data-science education and should be included in future discussions to ensure that students are well-equipped to handle the ethical challenges of the field. This workshop has laid the groundwork for a comprehensive approach to data-science education, one that promises to drive progress and inspire the next generation of data scientists in an inclusive way.

List of Participants

The diverse group of individuals who participated in the DSAIL-GeJuSTA Data Science Education Workshop (Fig. 7, Table 1).

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Hosting institution

Centre for Data Science and Artificial Intelligence, Dedan Kimathi University of Technology.

Ethics and security

This workshop was conducted after gaining ethical approval from the **Dedan Kimathi University of Technology Scientific Ethics Review Committee (DeKUTSERC)** (Approval Number: DeKUT/ISREC/03422/002) and a licence from **NACOSTI (License Number: NACOSTI/P/23/27184).**

Conflicts of interest

The authors have declared that no competing interests exist.

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Figure 1.

Gabriel giving an account of gender representation analysis in African universities.

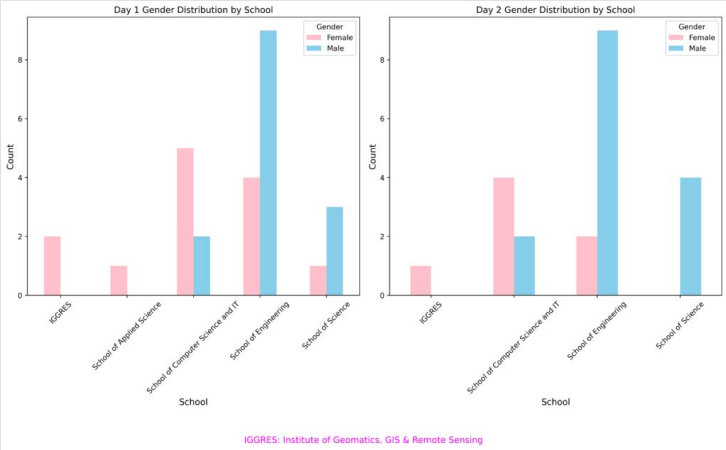

Figure 2.

The Gender Distribution by School for days 1 and 2 of the DSAIL-Tech4Wildlife workshop.

Figure 3.

Dr. Nderu during his presentation.

Figure 4.

Mr. Matogo from IBM giving an overview of their digital learning platform.

Figure 5.

Dr. Mukami: Developing a data-science curriculum in universities.

Figure 6.

The round-table discussion on structural barriers that women in STEM face, led by Dr. Mutuku.

Figure 7.

A group photo of participants who physically attended the workshop.

Table 1.
List of participants.

First Name	Last Name	Affiliation
Austin	Kaburia	Centre for Data Science and Artificial Intelligence, Dedan Kimathi University of Technology
Cedric	Kiplimo	Centre for Data Science and Artificial Intelligence, Dedan Kimathi University of Technology
Celina	Mfala	Nelson Mandela African Institute of Science and Technology
Ciira	Maina	Centre for Data Science and Artificial Intelligence, Dedan Kimathi University of Technology
Clinton	Oduor	Amini Technologies
David	Mwathi	Chuka University
Edna	Too	Chuka University
Edward	Ombui	Africa Nazarene University
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