AI Ethics in Higher Education: Research Experiences from Practical Development and Deployment of AI Systems

Joyce Nakatumba-Nabende, Conrad Suuna, and Engineer Bainomugisha

1 Introduction

Artificial Intelligence (AI) offers tangible benefits in several application domains like disease diagnosis in health (Muyama et al. 2021; Mahmood et al. 2021), crop disease diagnosis in agriculture (Brahimi et al. 2017; Owomugisha and Mwebaze 2016; Mbelwa et al. 2021) transport and infrastructure (Floyd 2020), environmental monitoring (Coker et al. 2021), and natural language processing (Sefara et al. 2021; Adelani et al. 2021; Nabende et al. 2021; Kabiito and Nakatumba-Nabende 2021). Increasing access to large datasets, improvements in AI models, and accessibility to computational resources have led to growth in the area of AI and particularly machine learning (ML). The growing use of machine learning, in turn, has led to discussions and concerns around ethical aspects. One central ethical concern is about the data used for training machine learning models. For example, an AI-judged beauty context showed that it was biased in the selection of its winners because the model was trained on data that had involved individuals with light-skin tones compared to darker skin tones (Pearson 2016). When an ML algorithm is trained on a dataset that has underlying biases, it can make poor predictions on the underrepresented population. Moreover, if algorithms trained on biased data sets are adapted and used in real-life settings they can exacerbate the discrepancies observed in the data (Liu et al. 2019). Therefore, ethical aspects must be taken into consideration at all stages of building and deploying AI systems.

J. Nakatumba-Nabende (✉) · C. Suuna · E. Bainomugisha
Department of Computer Science, School of Computing and Informatics Technology, Makerere University, Kampala, Uganda
e-mail: joyce.nabende@mak.ac.ug

C. Suuna
e-mail: conrad.suuna@students.mak.ac.ug

E. Bainomugisha
e-mail: baino@mak.ac.ug

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In African Universities, three approaches are being taken to grow the AI and data science education and research ecosystem. This has been through the establishment of AI-related data science degree programs (Butcher et al. 2021), setting up AI research labs and centers of excellence, and implementation of practical AI projects. The growing potential of AI has resulted in the establishment of new or strengthening existing university programs in the areas of machine learning, artificial intelligence, bioinformatics, and data science. This is expected to enhance the development of local capacities in AI and data science across the continent. The research labs have been set up within universities and they use AI and machine learning to solve multidisciplinary and practical challenges across several domains in Africa (Makerere Artificial Intelligence Lab 2021; Research Groups—Wits University 2021; Home | CAIR, 2021; Ciira Wa Maina's Homepage 2021; Data Science for Social Impact Research Group—Home 2021). The research labs enable the implementation of practical AI case studies. This provides opportunities for the integration of AI ethics and responsible AI approaches into the educational space. In this paper, we follow these approaches to build a case on the integration of ethical AI around research, innovation, and capacity building. An ethical AI ecosystem should be spearheaded by educators and researchers within the higher institutions of learning. The education sector at universities has the potential to influence students who eventually interact with data collection, model development, and eventual AI system deployment. This is also referred to as the data-to-impact pipeline that is necessary for creating AI solutions and systems (Nakatumba-Nabende 2021). The research labs help to bridge the current gap around the integration of AI ethics in education from a practical research perspective.

In a recent survey by UNESCO, one of the main recommendations for capacity building in organisations to address ethical challenges was to develop educational programs that include AI ethics across different levels in educational institutions development in Africa (Sibal and Neupane n.d.). To fill this gap, this paper presents results from selected universities in Africa to understand the state of AI ethics in graduate programs and experiences in the practical AI systems implemented by AI research labs at these universities. Specifically, we address two research questions:

RQ1: *What is the state of AI ethics in computer science programs at African Universities?*
RQ2: *What are AI ethics issues, lessons, and best practices arising from the practical AI systems implemented by the AI research labs on the continent?*

Our results show that AI ethics is embedded in traditional courses such as research methods, although specific AI ethics courses are also emerging. There is a growing trend of the establishment of AI degree programs and research labs in African higher educational institutions. AI labs are playing a pivotal role in developing relevant curricula and content to support AI ethics research and training. Research work in AI ethics is minimal across the institutions and this is attributed to the growing capacity specifically in the AI ethics field.

The rest of the chapter is structured as follows. In Sect. 2, we detail the topic of AI, AI ethics, the state of AI education, and research in Africa. Section 3 describes

the research methodology that we used. Section 4 discusses the results and Sect. 5 concludes the paper.

2 Background

2.1 Ethical Artificial Intelligence

AI technologies are being encountered in several areas of our day-to-day life (Yu et al. 2018). The term AI is frequently used to classify systems that possess characteristics such as learning from experience, discovering meaning, and have the ability to reason (Builtin 2021). Ethical AI speaks to a moral compass that enables people to make ethical decisions during the development and deployment of AI models. This area is now a major focus around the design, development and deployment of AI systems.

There has been growth in the formulation of guidelines, frameworks, consultations around ethical AI from several stakeholders including academia, non-governmental organizations, industry, governments, and international bodies. The Montréal Declaration for Responsible Development of Artificial Intelligence was drafted from an academic perspective and was formed out of a forum on the socially responsible development of AI (Universite de Montreal 2018). Several companies in the industry have also come up with their specific AI ethical principles, for example, Deepmind Ethics and Society Principles (DeepMind 2021), Microsoft AI Principles (Microsoft 2021), and Google AI principles (Google 2021), OECD's Recommendation of the Council on Artificial Intelligence (OECD 2021), and AI4People ethical framework (Floridi et al. 2018). As digitalisation is on the increase on the African continent, a number of African countries are also coming with data protection and privacy acts. Work in AI ethics is also fostered by conferences for example the ACM Conference on Fairness, Accountability, and Transparency (FAccT) that brings together academics and industry to discuss issues around AI fairness, accountability, and transparency. The idea is that we can be able to consider these existing AI ethical frameworks as a basis and use them as a baseline to highlight what applies to the African context.

2.2 AI Ethics Education

Several studies by academia, government, and industry have emphasized the need for developing ethical AI education among key players in the AI ecosystem including, developers, government agencies, users, NGOs, and industry (Taylor and Deb 2021; Raji et al. 2021). AI ethics education should be an important component of AI education at universities if we are to produce ethically responsible AI practitioners. As highlighted in (Raji et al. 2021), how AI ethics is taught is a reflection on how AI practitioners are trained and it shows how academia speaks to practice. This implies that

the delivery of AI ethics education at universities is important to ensure it does what it is supposed to do. The suitability of African universities as platforms to address AI ethics education is underwritten by their unique position as conveners, trainers, and mentors of youthful talent, which is more amenable to transformation into future AI developers and decision-makers. Universities are also well networked with governments and private industry, which provide pathways for applied engagement of AI trainees and easier policy uptake of research products.

As shown in Fig. 1, AI ethics education in African universities can be approached from two perspectives. The first approach is through curriculum design and formal instruction in AI ethics where the focus can also draw heavily on existing AI ethical frameworks, guidelines, and principles. Secondly, the formal instruction of AI ethics should be approached from AI research labs' perspectives. These are research labs that are undertaking multidisciplinary AI research projects and they provide practical examples of approaches to AI ethics (Raji et al. 2021). The research labs present an opportunity to emphasize the documentation of the implementation of practical AI local case studies and practical experiences of AI ethics in the African continent. This is because the research labs can also act as a reference and inform AI ethics education. AI research labs should be multidisciplinary and provide a collaborative approach across several disciplines that are critical for interdisciplinary thinking (Kim 2019). This introduces the experience that is required for example through the use of real-world image datasets, for example in healthcare that can greatly foster students to think about aspects of informed consent, privacy, confidentiality, safety, transparency, bias, legal issues even before the AI model development process (Borenstein and Howard 2021; Rigby 2019; Katznelson and Gerke 2021).

Attempts have been made to combine experiences from practical AI projects into the teaching of AI programs for example through a technical curriculum (Williams

Fig. 1 Key ingredients of AI ethics education in African universities

et al. 2020; Burton et al. 2017). However, this is not sufficient and we propose that AI ethics education should be incorporated within the entire AI curriculum that all computer science university students have to follow. This should be done in a case study-based approach as templates for students to practically think about and experience the AI ethical aspects (Burton et al. 2017).

3 Methodology

The study aims to understand how AI research labs and practical research projects are informing AI ethics teaching and education in African Universities. In this section, we describe the methodology and processes used to answer the research questions (**RQ1** and **RQ2**) and derive the results presented in this paper. We employ a blend of expert interviews and case study analysis of the research labs. We received feedback from experts and faculty from 12 Universities and 6 African countries based on a survey in Appendix One. The country distribution includes East Africa (Uganda, Kenya, and Tanzania), Southern Africa (South Africa), and Western Africa (Nigeria and Senegal). Figure 2 shows the distribution of the countries selected representing three African regions.

The respondents included senior faculty, research lab heads, and researchers. A survey was developed to gather feedback from universities and research labs. Institutions include Busitema University, Meru University of Science and Technology, Makerere University, Dedan Kimathi University of Technology, Mbarara University of Science and Technology, Central University of Technology—Free State, Muhimbili University, University Alioune Diop of Bambey, Jaramogi Oginga Odinga University of Science and Technology, Nelson Mandela African Institution of Science and Technology, Federal University Oye Ekiti and the University of Port-Harcourt.

The survey questionnaire consisted of closed and open questions and covered two categories of AI ethics education and research. The respondents were identified through the analysis of institutions that have participated actively in the Africa data science communities such as Data Science Africa (DSA) (Data Science Africa 2021) since its inception in 2013 as well as emerging in-country networks such as the DSA Ugandan chapter (DSA Uganda 2021). The survey was complemented by the authors' knowledge and experience accumulated over the years from designing AI curriculum and involvement in undergraduate and graduate education, implementation and deployment of practical AI systems in Africa, supervision of graduate research and leadership of Computer Science departments and AI research labs. We undertook a document review and analysis of the work carried out in the research labs in the educational institutions and selected case studies of practical implementation of AI systems in the research labs. The case studies considered as part of this research are summarised in Table 1.

Fig. 2 Country distribution of the selected Universities and AI research labs

We analyzed the data from the universities and research labs to derive and form the common themes. The themes were categorised and assigned to the two research questions i.e.:

RQ1: *What is the state of AI ethics in computer science programs at African Universities?* and
RQ2: *What are AI ethics issues, lessons, and best practices arising from the practical AI systems implemented by the AI research labs on the continent?*

Table 1 Mapping of the case studies considered for AI ethics at African Universities

Case study at AI research labs and Universities	What the case study represents
Makerere AI Lab—mCrops project[a]	Practical project implementation of AI for building crop disease diagnosis models for agriculture in Uganda (Owomugisha and Mwebaze 2016)
Makerere AI Lab—AirQo project[b]	Practical implementation of AI for environment monitoring, modeling, and analysis in Uganda (Coker et al. 2021)
Makerere AI Lab—rCrops project[c]	Practical implementation of AI for building speech recognition models based on radio streams in Uganda (Akera et al. 2019)
Dedan Kimathi University of Technology	Practical implementation of the use of the internet of things (IoT) for water quality monitoring (Mokua et al. 2021)
Marconi Machine Learning Lab[d]	Practical project implementation of building AI for cervical cancer diagnosis in Uganda and AI systems for passion fruit disease identification (Katumba et al. 2020)
Makerere AI Lab—Ocula project[e]	Practical project implementation of building AI for microscopy diseases: malaria, tuberculosis, and intestinal worms in Uganda (Muyama et al. 2021; Quinn et al. 2016)
Nelson Mandela African Institute of Science and Technology	Practical project implementation of building AI for poultry diseases diagnostics and bioinformatics methods for small and medium-scale poultry farmers in Tanzania (Mbelwa et al. 2021)
Muhimbili University[f]	Adopting Ada (an artificial intelligence AI-system) to support medical decision making during the process of diagnosis in Tanzania

[a] mCrops project. http://34.242.164.142/mcrops/
[b] AirQo. https://airqo.africa
[c] https://air.ug/projects/#thumb9
[d] https://ml.netlabsug.org
[e] https://air.ug/microscopy/
[f] https://drp.muhas.ac.tz/Research

4 Results and Discussion

In this section, we present results from the analysis and provide a discussion of the lessons and emerging issues to help inform academicians and researchers of AI ethics at African institutions of higher learning. Table 2 provides a summary of the lessons and emerging issues from the analysis. Lessons L1-4 are the lessons and issues that emerged from the AI ethics education from the selected African universities, while

Table 2 Lessons and emerging issues of teaching AI Ethics in higher education in Africa

Theme	Lessons and emerging issues
AI ethics education in African Universities	**L1**: AI ethics is embedded in traditional research methods, although specific courses are emerging
	L2: AI ethics is offered across undergraduate and postgraduate levels at the University
	L3: There is the use of global AI ethics frameworks with some glocalisation
	L4: Institutional AI ethics local capacity is still developing
Role of AI research labs and practical projects in AI ethics education at African Universities	**L5**: African Universities are establishing AI labs
	L6: Minimal AI ethics-specific research themes
	L7: AI labs are providing relevant content for curricula and serve as a vehicle for experiential learning for AI ethics
	L8: AI labs are playing a critical role in promoting AI ethics research and training

L5-8 presents the results on how AI research labs and practical project implementations are shaping the landscape of teaching AI ethics in University programs as well as graduate research. AI ethics in education is an emerging topic, therefore, these lessons are not necessarily conclusive. Moreover, the teaching of AI ethics is also dependent on changing policy and regulatory landscape at national and internal levels. For example, African governments are formulating policies, strategies, and regulations that could have implications on the priority of AI ethics in education and practice, for example, the Data Protection and Privacy Act exists in Uganda (The Data Protection and Privacy Act 2019) and Kenya (The Data Protection Act 2019).

4.1 AI Ethics Education in African Universities

Under this theme, we set out to answer the research question "*RQ1: What is the state of AI ethics in computer science programs at African Universities?*" to understand the level of awareness of AI ethics among University degree programs, approaches that are employed by African Universities to teach AI ethics at Universities and any emerging issues. AI as a field where AI ethics fall is still developing across the selected African institutions. There are emerging AI-specific courses in about half of the institutions surveyed. Makerere University in Uganda has revised its Master's in Computer Science programme to include a specialised track on AI and Data Science (Department of Computer Science 2021).

We found that AI ethics is embedded in traditional research methods courses, although specific short courses and modules are emerging (**L1**), other institutions are in the process of revising their curricula and integrating AI ethics courses. From the selected institutions 40% of the respondents indicated that AI ethics is embedded in research methods courses, while in other cases teaching of AI ethics is considered as modules in AI and machine learning courses such as Machine Learning, Artificial Intelligence, Data Mining, and Data Processing. Designing curricula to accommodate various courses is often challenging and therefore the approach of blending ethics across is sometimes considered an optimal approach given its cross-cutting nature. Teaching and delivery of AI ethics courses are largely theoretical with minimal practical class projects. Topics covered include algorithmic bias and fairness, gender, explainability, security and privacy, and data ownership and protection. In some institutions, standard curricula are complemented by specialised modules, professional courses, reading clubs, institutional research ethics committees, seminars, and conferences. For example, past editions of the Data Science Africa workshop, whose audience is largely African University students and faculty, have featured talks and panel discussions on Ethics in AI with topics on ethical challenges in health, security aspects for data engineering. Moreover, Makerere University has developed Open AI Training modules with a specialized topic on the identification and elimination of biases in AI training data.[1]

AI ethics is offered across undergraduate and postgraduate levels in the University (**L2**) with the majority of the institutions teaching AI ethics at the Bachelor's degree level, followed by the Master's programs, and professional short courses and modules. Institutional AI ethics local capacity is still developing (**L4**) at many African universities, with only a few faculty involved in AI research in general and minimal graduate research in AI ethics (20%). This suggests that AI ethics is considered as a crosscutting concern than a standalone research topic or theme for research. There is the use of global AI Ethics Frameworks with some glocalisation (**L3**), for teaching and implementation of practical AI research projects. Faculty reported the use of several global AI ethical frameworks as discussed in Sect. 2, for example, AI Now Reports, Microsoft AI principles, DeepMind Ethics and Society Principles, etc. The use of AI ethical frameworks during AI project development and deployment was low at 10% of the respondents. This suggests a lack of awareness of global AI ethics frameworks or limited capacity in considering ethical issues. In the future, it would be interesting to undertake a detailed review of the fit of global AI ethical frameworks for the AI projects in the African context and to explore any glocalisation opportunities therein.

[1] https://github.com/AI-Lab-Makerere/courses-on-open-and-unbiasedAI-training-data.

4.2 Role of AI Research Labs and Practical Projects in AI Ethics Education at African Universities

Here we present the emerging lessons and issues under the research question "What are AI ethics issues, lessons and best practices arising from the practical AI systems implemented by the AI research labs on the continent?". The purpose of this research question was to find out the role of research labs in AI ethics education and research in African universities and any emerging ethical issues from the implementation of the practical AI projects in the African context. African Universities are establishing AI labs and centers to propel AI research and education on the continent (**L5**), with 68% confirming the existence of an AI research lab at their institution. The major application domains of focus for the research labs include Health (75%), Agriculture (50%), and Environment (42%) indicating the priority of African institutions to undertake AI research that addresses key development challenges facing the continent (Fig. 3). These themes are consistent with those identified in previous studies on the role of AI on social impact in emerging economies (Tomašev et al. 2020). The major technical sub-themes across the selected African institutions and countries include Computer Vision, Machine Learning, Artificial Intelligence, Robotics, Natural Language Processing, Mobile Computing, the Internet-of-Things, and Human-Computer Interaction. There are minimal AI ethics-specific research themes in the AI research labs (**L6**) and graduate research in AI ethics is still in its infancy. In some institutions, AI research labs are establishing sub-groups focussing on AI ethics. However, AI in graduate research is still low with only 20% of the faculty surveyed indicating that their research labs have graduate students researching in the area of AI ethics. No single institution reported an AI ethics research paper. This finding shows a gap in raising the profile of AI ethics research. Some institutions attributed this to the lack of funding and lack of local capacity to research in the area.

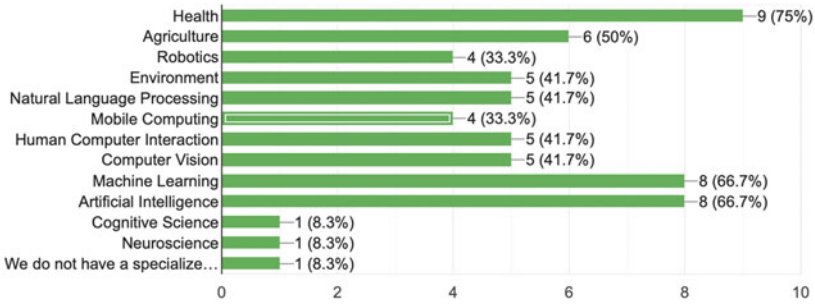

Fig. 3 Major focus areas and application domains of AI research labs

Table 3 AI ethics issues identified in practical projects implemented by the AI labs

Research focus	AI ethical considerations
AI in health	Informed consent, privacy, confidentiality, safety, transparency, bias, explainability, algorithmic fairness, explicability
AI in agriculture	Transparency, inclusion, security, privacy, accuracy, data ownership, explainability, explicability
Natural language processing	Bias (gender, racial), exclusion, discrimination, diversity, algorithmic fairness, transparency, explicability
AI in environment	Security and data privacy, economic and political harm, misuse, algorithmic fairness and biases, accuracy, explainability

Despite the minimal AI ethics research topics, AI research labs are providing relevant content for AI ethics curricula and serving as an essential vehicle for experiential learning (**L7**). Development and delivery of AI ethics curricula on the African continent can be at risk of replicating content taught elsewhere without much consideration of the relevance and fit to the unique AI ethics issues for the continent. AI research labs are involved in the implementation of AI projects and can use that experience to enrich AI ethics curricula with real-world examples from the development and deployment of AI systems. Take, for example, the AI lab at Makerere University first started a specialised track in Computer Vision in 2009 and recently leveraged the practical experience in developing and deploying local AI systems to improve the curricula and develop relevant content. Further, AI labs are critical in contributing to relevant graduate education and research in AI ethics (**L8**). African in general lacks sufficient local case studies to support the training of AI ethics and AI topics. Therefore documentation of AI ethics arising from local AI practical projects that are being implemented at the labs is critical in the quality of AI ethics teaching and delivery. Table 3 shows an overview of the AI ethical issues derived from the example practical projects implemented by the AI research labs.

The institutions surveyed employ different approaches to complement AI training and research including research seminars especially for graduate students, mentorship, practical AI ethics research topics, internships, and student job opportunities. Although AI labs reported having experienced AI ethics issues in research project implementation, the documentation of the issues arising from the practice is still lacking. This potential area for future work is a step towards developing AI ethics education and research in Africa.

5 Conclusion, Limitations, and Recommendations

This paper presents the state of AI ethics in education at African Universities and the critical role AI research labs play to support AI ethics teaching and education. Although the number of use cases and universities is limited, we hope that the results of this study are important in providing a framework for the use of AI research

carried out in enhancing the teaching of AI ethics in other African universities. The field of AI ethics and in general AI and machine learning are emerging across African Universities. The AI research labs can help to demystify the potential and applicability of AI and machine learning in the African setting, thereby leading to increased interest in the field for students, staff, and the industry. Previously the lack of local AI and machine learning projects led to the perception that AI and machine learning are only applicable to developed countries and teaching of topics such as AI ethics was largely theoretical. This is also applicable to the teaching of AI ethics without local examples that students and staff can connect with. We recommend that African Universities undertake the following steps to improve the teaching of AI ethics (1) Development of AI ethics training programs, curricula, courses, and relevant content informed by practical *local* experiences from AI research labs. (2) Documentation of AI ethical issues in local case studies practical projects and making these accessible to students and faculty (3) Undertaking AI ethics-specific research in the research labs as means to grow local capacity. (4) *Glocalisation* of the existing AI ethics frameworks and using the resulting customised frameworks in teaching and research project implementation. These should be applicable to the arising aspects of ethical AI within the African context.

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Appendix 1: Survey Questions

1. Your Name
2. Email Address
3. Country of residence
4. University/Institution
5. Does your institution offer any specific courses on AI ethics?
   - Yes
   - No
6. Under what courses are AI ethics taught in your institution (e.g., Machine Learning, Artificial Intelligence, Data Science, Research Methods)?
7. At what level are the AI ethics courses offered in your institution?
   - Bachelors
   - Masters
   - Ph.D.
   - Short courses

8. How are AI ethical issues being delivered in teaching at your institution?
    - Theoretical classes
    - Practical class projects
    - Other…
9. What other ways is AI ethics taught/delivered in your institution (if any)?
10. What guidelines/frameworks are being used for teaching AI ethics in your institution?
11. Do you have any graduate students undertaking ethics in AI as a research topic/focus?
    - Yes
    - No
12. What example research topics are being undertaken by the student(s)?
13. If AI ethics is not being taught to students, what effort is being made to make students aware of AI ethics?
14. What efforts are being put in place, through teachings/ practices to build local capacity in AI ethics?
15. Does your institution have AI or ML Research labs?
    - Yes
    - No
16. Is AI ethics one of the research focus areas in your institutional labs?
    - Yes
    - No
17. What is the research focus/application domain of AI labs in your institution?
    - Health
    - Agriculture
    - Robotics
    - Environment
    - Natural Language Processing
    - Mobile Computing
    - Human-Computer Interaction
    - Computer Vision
    - Machine Learning
    - Artificial Intelligence
    - Cognitive Learning
    - Other…
18. How is the research focus/work being done in your institutional lab used to strengthen the teaching and delivery of AI ethical courses?
19. Describe any AI ethics issues that you have experienced in your research project implementation.

20. How are AI ethical issues being addressed in the research or in the practical development of the AI applications at your institution?
21. How many people are involved in the different AI research areas at your institutional labs?
    - Below 30
    - 30–60
    - Above 60
22. Do you use any AI ethics guidelines/frameworks during system development and deployment in your institutional labs?
    - Yes
    - No
23. Please specify any frameworks, if any, being used in the development and deployment of the systems.
24. Are there any ethical issues that emerge from the AI systems being developed in the institutional labs?
    - Yes
    - No
25. How are they handled?
26. Do you have any published works in AI ethics?
    - Yes
    - No
27. Provide links to the published work.

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