

CHALLENGES AND OPPORTUNITIES IN INTEGRATING ARTIFICIAL INTELLIGENCE EDUCATION AT THE UNIVERSITY OF BOTSWANA: ADDRESSING INFRASTRUCTURE AND EDUCATIONAL PRIORITIES FOR A KNOWLEDGE-BASED SOCIETY

K. Mashaba¹, R. Monageng¹, M. Kgwadi¹, R. Chukati², and P. A. Majoo³

¹*Mechanical Engineering Department, University of Botswana, Gaborone, Botswana; mashabak@ub.ac.bw*

²*Botswana Accounting College, School of Computing and Information Systems, Gaborone, Botswana*

³*University of Johannesburg, College of Business and Economics, Department of Information and Knowledge Management, Johannesburg, South Africa*

Abstract: Botswana, ranked 64th in economic performance and productivity according to the IMD World Competitiveness Yearbook 2024, since joining it has made significant improvement in enhancing its skilled workforce and educational systems. Despite increasing awareness, the integration of artificial intelligence (AI) in education remains limited. AI, which automates tasks, holds significant potential for preparing engineers in a knowledge-based society. This study examines why the University of Botswana has not established robust AI programs and explores factors contributing to the absence of a dedicated AI degree. Key challenges investigated include inadequate infrastructure for fast connectivity, though efforts are underway with a fiber optic project from Namibia aimed at improving internet speeds. Significant investment is needed to modernize network capabilities and enhance economic competitiveness. While the Faculty of Computer Science offers related courses such as data structures, algorithms, and data mining, they focus more on theoretical and practical computing applications than standalone AI disciplines. Similarly, AI concepts in Electrical and Mechanical Engineering are integrated within broader engineering disciplines. Addressing these challenges requires understanding educational priorities and resource allocations necessary to develop comprehensive AI programs aligned with industry demands. The study employed a mixed-methods approach, and found that the current AI-related courses are misaligned with industry demands and technological advancements, largely due to outdated content, insufficient faculty expertise, and inadequate infrastructure with Stakeholders expressing a strong need for the curriculum to evolve in order to better prepare students for the dynamic field of artificial intelligence and to keep up with technological changes.

Key words: Knowledge-based society, AI programs, Educational priorities, Industry demands, University of Botswana

1. INTRODUCTION

Botswana is a developing country, currently ranked number 64th in performance and productivity according to the IMD World Competitiveness Yearbook 2024 (IMD,2024). Regarding its skilled workforce and educational development, the country has increased its ranking for three consecutive years since joining the world economic performance rankings in 2021. One area of focus has been the use of artificial intelligence in the education sector, where awareness has increased but application remains lacking. Artificial intelligence involves the use of computers to perform tasks that were traditionally executed by humans (Roll, 2016). Internet connectivity bandwidth has played a pivotal role in the application of artificial intelligence in preparing engineers for a knowledge-based society.

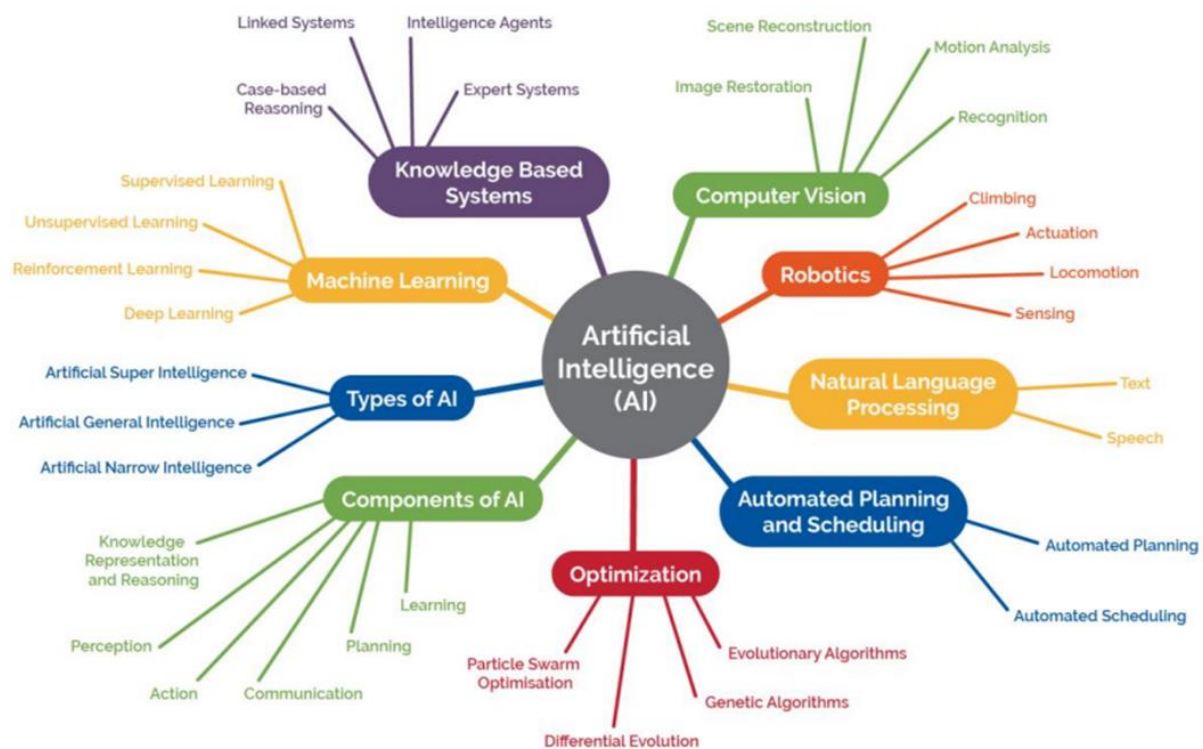


Figure 18. Components of AI Regona et al, (2022).

To remain up-to-date, fast connectivity and quick task execution speed are imperative for economic productivity. However, the country lags behind in infrastructure that supports rapid connectivity (IMD,2024). Currently, it is in the process of laying fiber optic cables from Namibia. Once this project is completed, it is expected that internet connections will become faster and more reliable. Regarding the cost of these infrastructure projects and others in the same area, significant investment is required to modernize and expand the network. The government has allocated substantial funds to the fiber optic project, aiming to bridge the current connectivity gaps and boost overall economic competitiveness and at the same time drives the use of AI.

The primary drivers of the application and awareness of artificial intelligence remain within learning institutions (George, 2023) and the government. However, some of these institutions do not offer robust programs solely dedicated to artificial intelligence and machine learning. For instance, there is limited countrywide degree program in Botswana specifically focused on AI, despite its critical importance in today's knowledge-based society. The use of artificial intelligence in learning institutions could accelerate the learning curve through fast retrieval and analysis of vast datasets, thereby aiding in knowledge management. This potential benefit underscores the need for educational institutions to develop comprehensive AI programs that prepare students for the demands of the future job market (Perez, 2018).

It is notable that the Faculty of Computer Science in university of Botswana offers courses related to AI, such as data structures, algorithms, and data mining. However, most of these courses focus on theoretical foundations and practical applications in computing instead of being standalone disciplines in AI. Similarly, courses offered in Electrical Engineering and Mechanical Engineering are not explicitly branded as AI courses but rather integrated into broader engineering disciplines in the University of Botswana.

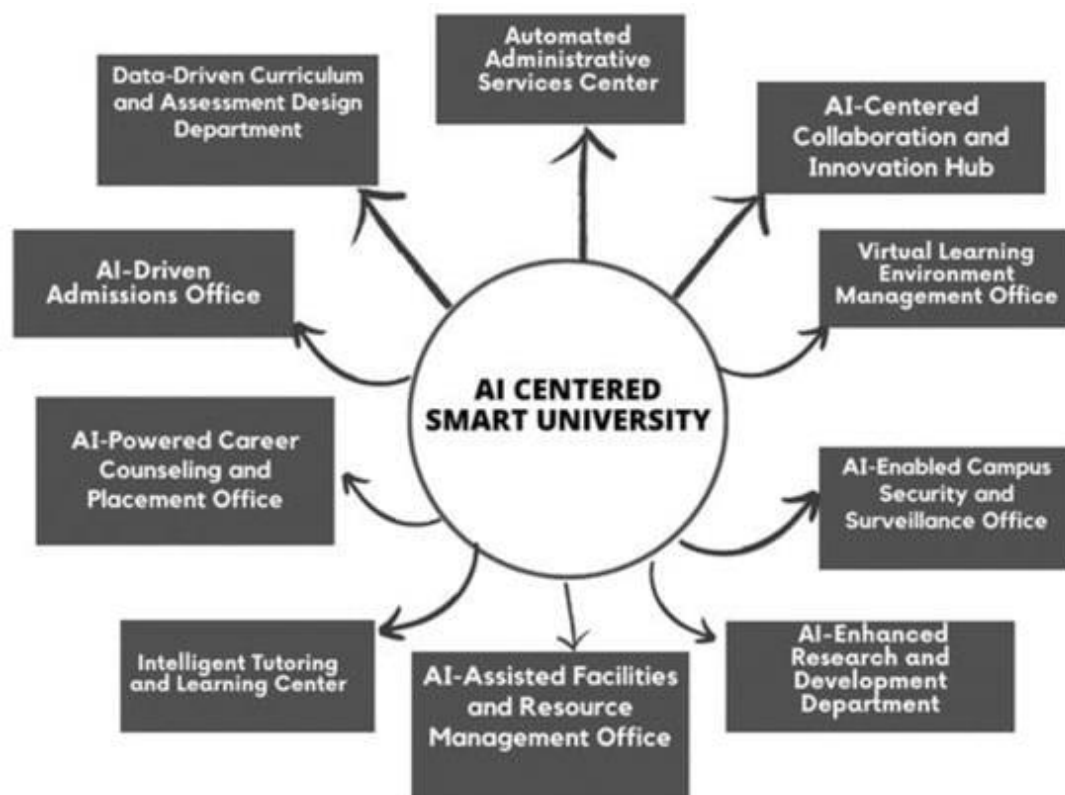


Figure 19. AI Smart University (George, 2023).

This study aims to investigate why the University of Botswana does not offer robust programs in artificial intelligence and to understand the factors contributing to the absence of a degree program in artificial intelligence at the university through literature review, document analysis expert survey focus group.

2. LITERATURE REVIEW

Artificial Intelligence (AI) has become part of our daily life (Jing, 2024). It is used in many applications, with the ability to mimic cognitive functions typically associated with human intelligence, including learning from experience, adapting to new information, and making decisions based on identified patterns. Deep machine learning algorithms, for example, allow systems to analyze vast amounts of data to identify trends and predict future outcomes with increasing accuracy. In the 21st century, in the era of 4th Industrial Revolution, technology has evolved to encompass sophisticated technologies not limited to robotics and computer vision. This broad field plays a pivotal role in today's fast-paced global economy, with easy access with the click of a button to Access Mountains of data sets with the help of deep machine learning, Robotics, and computer vision (Jaiswal et al,2022).

The study of autonomous systems or robotics has had a great impact on manufacturing systems and thus revolutionized industries by automating repetitive tasks and enhancing precision in manufacturing processes. The application of robotics is more visible in automated assembly lines and self-driving vehicles, with the ability to optimize efficiency and safety across various sectors. Moreover, computer vision technologies empower machines to interpret and understand visual information, ranging from facial recognition in security systems to medical imaging diagnostics.

The study of artificial intelligence (AI) is immensely important in the education sector, playing a pivotal role in enhancing human capacity and bolstering global economic competitiveness (George, 2023). In the Fourth Industrial Revolution context, businesses increasingly rely on AI-driven technologies to optimize operations and innovate their products and services. For instance, industries such as Botswana water utilities has transitioned from conventional digital water meters to advanced intelligent water meters marking a significant shift towards AI-integrated infrastructure.

Intelligent-meter deployment enhances efficiency and necessitates a workforce equipped with AI proficiency. Technicians and professionals capable of harnessing AI capabilities will be crucial for maintaining, optimizing, and innovating these new systems. Hence, integrating AI education as a core course or offering dedicated AI degree programs in universities becomes essential (Akinwalere 2022). These

educational initiatives prepare students for emerging job roles and foster a knowledge-based society capable of driving technological advancements.

By imparting AI skills through structured academic programs, Universities contribute to shaping a workforce that can meet the evolving demands of industries in the digital age (George, 2023). Moreover, fostering AI literacy among students ensures they are well-prepared to tackle the complex challenges and opportunities presented by AI-powered technologies (Akinwalere 2022). This proactive approach enhances individual career prospects and strengthens national and global competitiveness in the rapidly evolving landscape of the Fourth Industrial Revolution.

Al-Ali (2024) asserts that integrating generative AI has the power to completely transform teaching strategies. Policymakers must carefully consider its implications for pedagogy, ethics, and societal risks. Additionally, the author advocates for fostering equitable learning environments through proactive collaboration and partnerships to harness the potential of artificial intelligence fully. The literature review on AI in education has been growing exponentially since 2014, (Huang, 2023) and that can be depicted by fig 3 with an exponential increase of papers in AI. For instance, Chen et al. conducted a study on the impact of AI in education and found that it promotes faster learning and facilitates task management. AI applications in the education sector include the use of computers and related systems. The AI technologies that should be taught in higher learning institutions are more comprehensive than those driving autonomous machines, drones, and built-in systems.

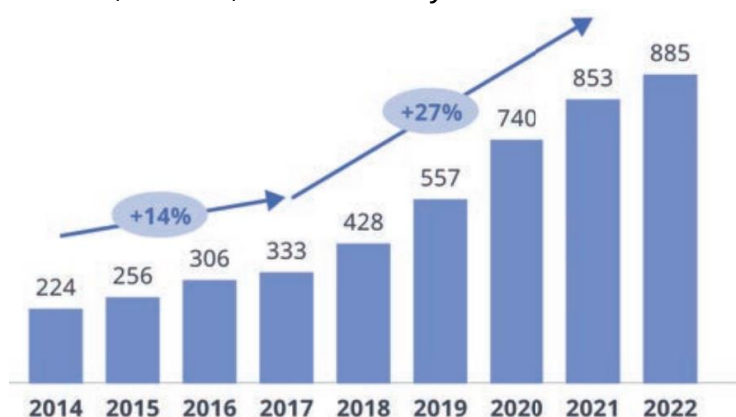


Figure 20. Web of Science article with AI robotics. Source (Huang, 2023).

Other typical examples occur in the classroom, where artificial intelligence (AI) serves as a personal tutor (Akinwalere 2022). AI systems can detect when students are falling behind on a particular topic or performing exceptionally well (Shukla, 2013). This real-time feedback allows educators to intervene promptly with personalized support, ensuring each student receives the guidance they need to succeed. Students are encouraged to develop problem-solving skills and analytical thinking by engaging with

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AI-driven educational tools. This approach enhances their understanding of the subject matter and cultivates a better cognitive learning style, as noted by Shukla (2013). The surge in AI-related jobs highlights a critical need for specialized training programs. As AI continues to evolve, there is a growing imperative for workforce upskilling to accommodate the influx of new roles and changing job requirements (Jaiswal et al,2022). This transformation is not merely a matter of adapting to technological advancements but also involves replacing traditional training methods with more agile and responsive educational models.

Storey and Beeman (2023) discuss the causal relationship between job growth in AI and the demand for updated training paradigms. They emphasize the importance of integrating new learning content that addresses the specialized skills demanded by AI-driven industries. This shift from conventional pedagogical approaches to dynamic training strategies is essential for preparing individuals to thrive in an AI-dominated future workforce.

The body of research on the integration and development of AI degree programs underscores a compelling case for the transformative impact that artificial intelligence can have on higher education. Studies consistently highlight the importance of establishing robust AI programs that cover theoretical foundations and emphasize practical applications and real-world experience. For instance, Zhang and Chen (2022) emphasize the need for a curriculum that balances theoretical knowledge with hands-on skills. Patel and Kumar (2021) point out the necessity of bridging the gap between academic learning and industry practice. Such findings are instrumental in guiding educational institutions toward developing comprehensive AI programs that meet current and future industry demands.

Challenges associated with implementing AI degree programs are significant but surmountable with strategic planning and investment. As Chen, and Lin (2020) identified, successful AI programs require alignment with industry needs, recruitment of qualified faculty, and cutting-edge infrastructure. These requirements highlight the importance of creating strong partnerships between universities and industry stakeholders to ensure that AI programs remain relevant and impactful. Roberts and Anderson (2019) further elaborate on the necessity of substantial investment in technology and curriculum development, suggesting that overcoming these challenges is crucial for the growth and effectiveness of AI education.

The benefits of establishing specialized AI degree programs are substantial, extending beyond academic advancements to broader economic and societal impacts. Liet al, (2024) illustrate that a well-designed AI curriculum can enhance students' job readiness by equipping them with technical expertise and an understanding of AI's

ethical implications. This preparation is vital for addressing AI technologies' complex challenges and opportunities, ultimately contributing to developing a skilled workforce capable of driving innovation in the AI sector. The potential for AI programs to foster a knowledge-based society and support technological progress aligns with the global trend toward AI-driven advancements.

Integrating AI education within university curricula is not merely advantageous but imperative for cultivating a skilled workforce capable of thriving in an AI-driven world. Unfortunately, in Botswana, there is currently a notable absence of institutions offering robust AI programs, except for Botswana Accountancy College and Botho University. This study seeks to investigate why the University of Botswana does not offer comprehensive AI programs and identify the factors contributing to the absence of a dedicated AI degree program. By examining these factors, the study aims to provide valuable insights into how educational institutions in Botswana can strategically incorporate AI education to effectively meet future workforce demands and contribute to advancing societal progress in an increasingly AI-driven global landscape using a mixed method approach

3. MATERIALS AND METHODS

This study utilized both a document analysis and stakeholder surveys methods to gather information about institutional priorities and educational policy followed by focus group to map out recommendations discussed by experts in the area of artificial intelligence. Document analysis was deployed to review current curriculum to identify potential constraints, human resources capacity and any other gaps that may have contributed to current shortcomings in the development of AI curriculum. The focus group survey conducted includes various stakeholders; Professors, Lectures, university administrators, students, industry expert and technical cadre designed to gather diverse range of perspective.

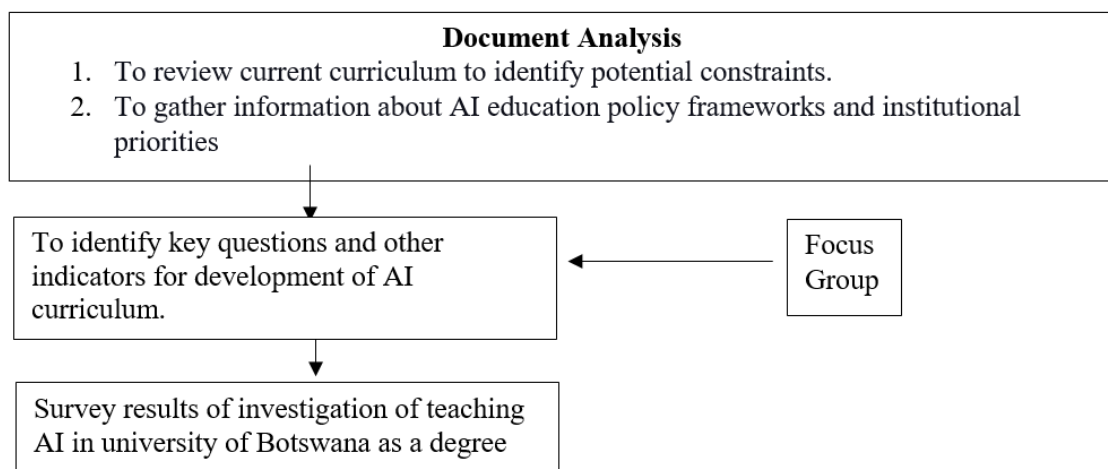


Figure 4. Research Map.

By synthesizing the results and findings from focus group, the study developed strategic recommendations and policy initiatives for the improvement of university curriculum. The suggested actions includes updating curriculum development guidelines, implementing faculty training programs, investing in infrastructure, forming industry partnerships, and enacting policy reforms. With the ultimate goal to enable the institutions to adapt to technological advancements, foster innovation, and prepare students to excel in an AI-driven global economy.

4. RESULTS AND DISCUSSION

The stakeholder survey results indicate significant interest and opportunity in integrating and developing artificial intelligence (AI) within the University curriculum. The majority of respondents emphasized the urgent need for substantial improvements in the current curriculum. Participants rated the integration of AI topics in the curriculum somewhat to very poorly (Fig 5), reflecting a general sentiment that the existing offerings need to better align with current industry demands and technological advancements. Common issues cited include a lack of faculty expertise, insufficient infrastructure, and limited funding (Fig 6).

Survey responses from a critical question in the focus group (***How do you think the current curriculum addresses the needs of students in the field of AI***) revealed a notable disparity between the current AI-related courses and the needs of both students and the industry. Many respondents indicated that the existing curriculum does not adequately prepare students for the evolving AI landscape, calling for updated course content to include practical, hands-on experiences and the latest tools and technologies (Fig 8). Critical barriers to developing a dedicated AI degree program include a shortage of specialized faculty and inadequate resources, hindering the effective delivery of AI education and research (Fig 6).

To address these challenges, the survey highlights several key recommendations. It is crucial for the University of Botswana to prioritize regular updates to the curriculum reflecting emerging trends and technological advancements in AI. Expanding faculty expertise through targeted hiring and professional development, improving infrastructure, and fostering stronger industry partnerships are essential steps toward enhancing the relevance and quality of AI education in the 21st century and 4th Industrial Revolution. Furthermore, integrating AI into the university's strategic vision is not just a step, but a significant leap towards the development of a robust AI program that aligns with both academic and industry expectations.

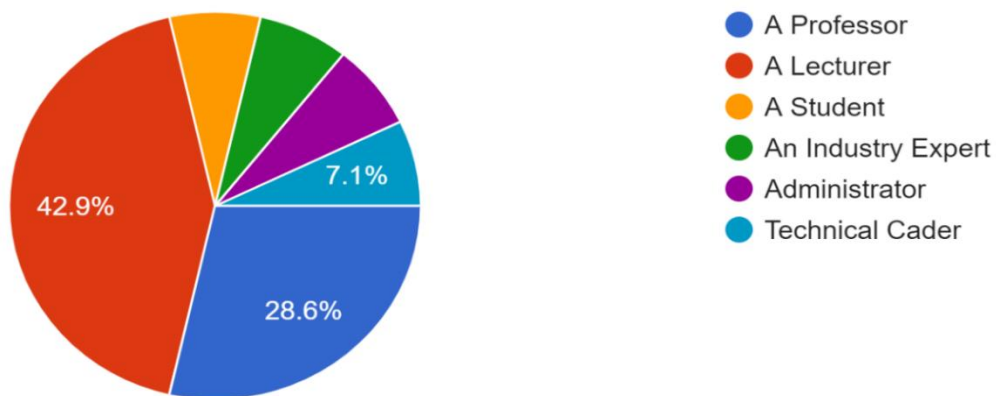


Figure 5. Pool Expert Chart.

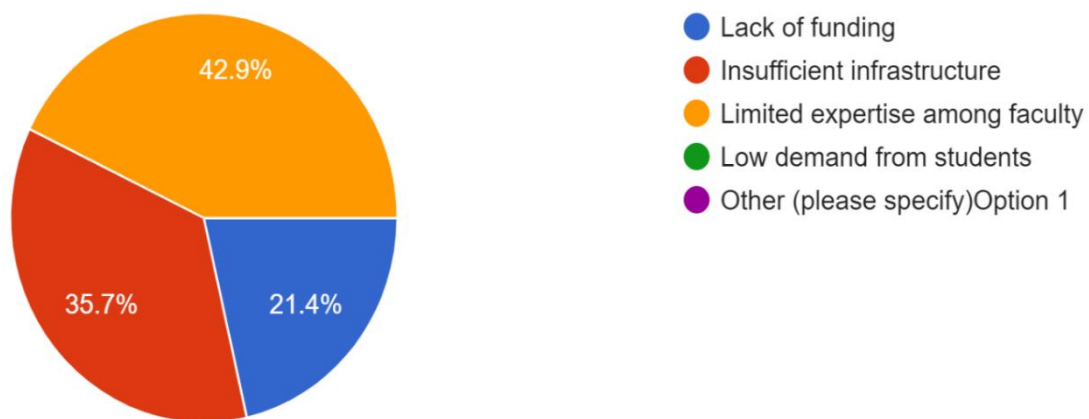


Figure 6. Barrier to AI degree.

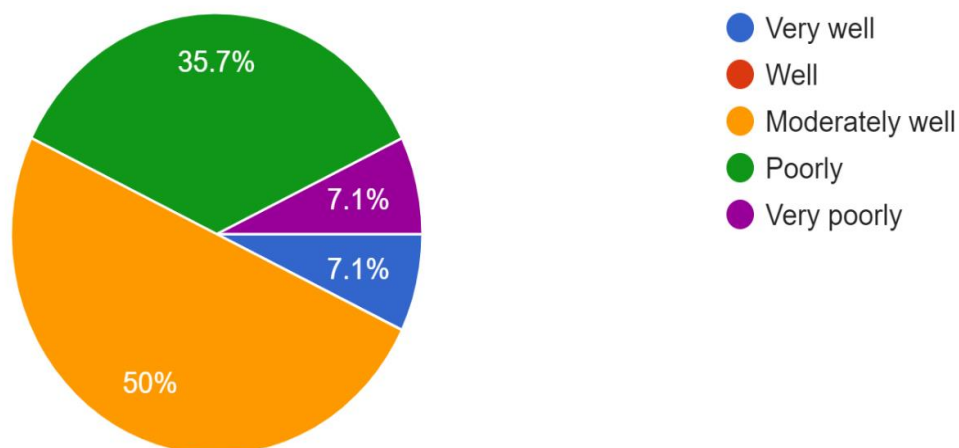


Figure 7. Current Course relevance to the industry.

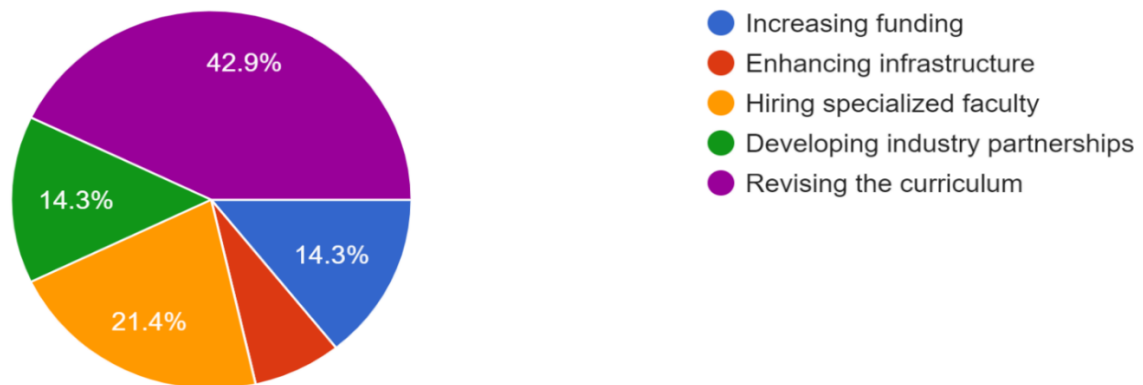


Figure 8. Critical step for AI Development.

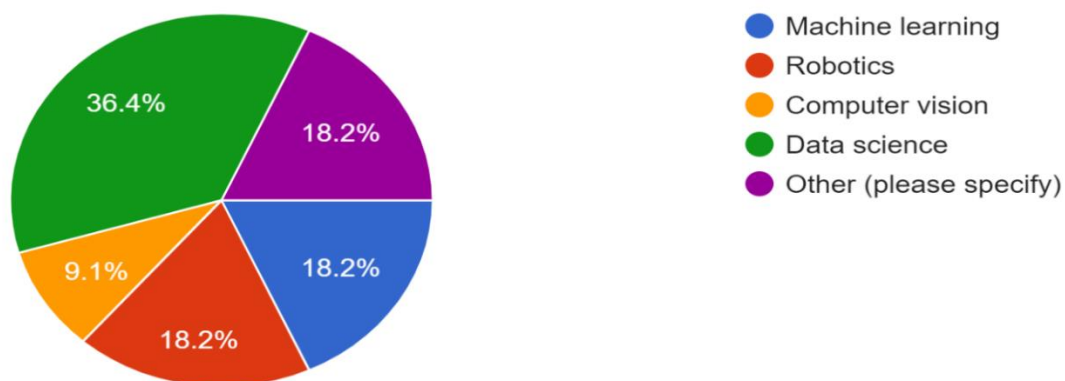


Figure 9. Most Beneficial course to Career Development.

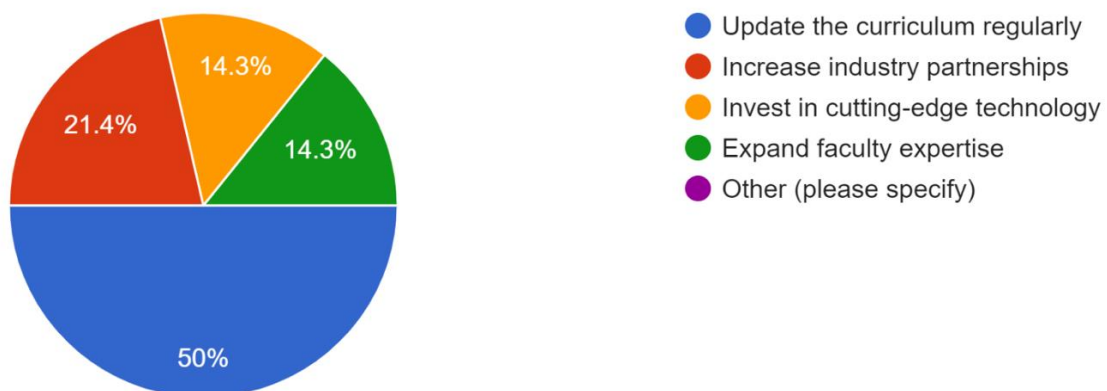


Figure 10. Important Recommendation to align AI program with industry.

5. CONCLUSION

The survey results and document analysis highlight significant challenges and opportunities concerning AI education at the University of Botswana. The current AI-related courses are misaligned with industry demands and technological advancements, largely due to outdated content, insufficient faculty expertise, and inadequate infrastructure. Stakeholders have expressed a strong need for the curriculum to evolve in order to better prepare students for the dynamic field of artificial

intelligence. The findings underscore a critical gap between the educational offerings and the practical skills required by the industry, pointing to an urgent need for strategic improvements. And our results are supported by (George, 2023) that universities that are powered by AI, will excel in many areas, teaching and learning, with evident results of reshaping education and economy.

To close the gap in AI Education, the University of Botswana should prioritize updating its AI curriculum to include contemporary tools, technologies, and hands-on experiences that reflect current industry standards. Recruiting additional specialized faculty and investing in professional development for existing staff and that will enhance the program's quality and relevance. Upgrading infrastructure and increasing funding are essential to support these educational improvements. Additionally, strengthening partnerships with industry leaders will ensure that the curriculum remains aligned with real-world applications and provides students with valuable practical experience. Implementing these recommendations will significantly enhance the AI program's effectiveness and better prepare students for future careers in artificial intelligence.

DATA AVAILABILITY STATEMENT

Data sharing is available per request for this article, new data were created and analyzed in this study.

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DECLARATION OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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