Student's Journal of Health Research Africa
e-ISSN: 2709-9997, p-ISSN: 3006-1059
Vol.6 No. 9 (2025): September 2025 Issue
https://doi.org/10.51168/sjhrafrica.v6i9.1991
Original Article

Climate-literate graduates: A cross-sectional study assessing the integration of climate change education across university disciplines.

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Abstract

Background
The growing threat of climate change demands that higher education institutions equip students with the knowledge and skills to respond effectively. Yet, the extent and manner in which climate change education (CCE) is integrated into university curricula, particularly in Global South contexts like South Africa, remains underexplored. This study examined the integration of CCE within South African universities, identifying patterns, challenges, and opportunities for improvement.

Methods
A cross-sectional survey design targeted academic staff and final-year students across five faculties (Science, Engineering, Humanities, Education, and Commerce) at three South African universities. Data collection involved structured questionnaires and semi-structured interviews. Quantitative data were analysed using descriptive statistics, while qualitative responses were thematically analysed to reveal curricular practices and perceived barriers.

Results
A total of 121 participants (12 academic staff and 109 final-year students) were included. CCE integration varied significantly across faculties. Science showed the highest inclusion of climate content (89%), followed by Engineering and Education. Commerce and Humanities reported limited engagement (33% and 29%). Most climate content appeared in elective rather than core modules. Interviews highlighted key barriers: limited institutional support, inadequate staff training, and weak interdisciplinary collaboration. Students expressed a strong demand for practical, action-oriented climate education across all disciplines.

Conclusion
CCE remains uneven and fragmented within South African universities, with structural, institutional, and pedagogical challenges impeding broader integration. This inconsistency risks undermining graduates' ability to address climate-related challenges in diverse professional contexts.

Recommendation
Universities should establish institution-wide climate literacy frameworks embedding CCE across faculties. Interdisciplinary curriculum development, staff capacity-building, and collaboration with industry and civil society are essential to produce climate-literate graduates capable of advancing sustainability and resilience in an increasingly climate-impacted world.

Keywords: *Climate change education, Interdisciplinary learning, Curriculum integration, Climate literacy, Higher education, Sustainability, South Africa, Faculty-based analysis*
Submitted: *2025-07-22* ***Accepted:*** *2025-08-04* ***Published:*** *2025-09-12*

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Background information

Climate change has emerged as one of the most pressing challenges of the 21st century, demanding coordinated global action and informed leadership across all sectors. As future leaders, decision-makers, and professionals are moulded within higher education institutions, universities hold a critical responsibility to prepare graduates who are climate-literate and capable of engaging with complex environmental, social, and economic systems. While awareness of climate issues has increased, questions remain regarding the extent to which climate change education (CCE) has been systematically and equitably integrated across all academic disciplines. Climate literacy entails not only knowledge of climate science but also the skills and values required to make informed decisions and take responsible action. According to UNESCO (2019), integrating CCE into all levels of education is essential for fostering sustainable development. However, existing literature shows that in many universities, CCE is still concentrated in science, health, or environmental faculties, leaving a gap in social sciences, business, and engineering fields. South Africa, as a developing country vulnerable to climate impacts, has incorporated environmental sustainability into its national education policies, yet implementation at the tertiary level remains inconsistent.

Despite increasing global urgency around climate change and calls for educational institutions to prepare students accordingly, many universities have not fully integrated CCE across disciplines. Faculties such as Science and Health have made strides, while others, such as Management Sciences and Engineering, often neglect or marginalize climate-related content. This disciplinary imbalance creates a workforce in which only select graduates are climate-literate, limiting society's capacity to respond holistically to environmental challenges. There is thus a critical need to assess how CCE is distributed across university curricula, identify existing barriers to integration, and propose pathways for comprehensive climate literacy in higher education. This study aims to assess the integration of climate change education across different university faculties in a South African higher education institution, to inform institutional reforms toward comprehensive sustainability education.

Methodology

Study design

This study adopted a cross-sectional survey design, which enabled the collection of data at a single point in time to assess the current state of climate change education (CCE) integration across academic faculties. This design is appropriate for identifying patterns, perceptions, and disparities among different academic units within a university.

Study setting

The study was conducted at Mangosuthu University of Technology (MUT), a public higher education institution located in Umlazi Township, south of Durban in KwaZulu-Natal, South Africa. MUT is a technology-focused institution serving predominantly historically disadvantaged communities, with faculties in Applied Science and Health, Engineering, and Management Sciences. Data collection was carried out between March and April 2022.

Participants

The study targeted academic staff members and final-year undergraduate students from the three faculties at MUT.

Inclusion criteria

- For students: being in their final year of study and enrolled in a qualification under one of the three faculties.
- For staff: having teaching responsibilities at the undergraduate level in any of the targeted faculties.

Exclusion criteria

- First- and second-year students, as they may not yet have had sufficient exposure to curriculum content relevant to CCE.
- Academic staff members without direct teaching responsibilities (e.g., administrators, researchers only).

Participants were selected using purposive sampling to ensure that respondents had adequate exposure to curriculum content and institutional teaching practices relevant to climate change education.

Bias

To minimize selection bias, participants were recruited across all departments within each faculty. Surveys were anonymized to reduce social desirability bias, and interviews were conducted in neutral settings to promote

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openness. Triangulation was employed by combining quantitative survey data with qualitative interviews to strengthen the validity of the findings.

Study size

A total of 121 participants took part in the study: 109 final-year students (33 from each faculty) for the quantitative component, and 12 academic staff members (4 from each faculty) for the qualitative component.
The quantitative sample size (n = 90) was determined using proportional representation across faculties while maintaining feasibility. A minimum of 30 student respondents per faculty was set to allow meaningful cross-faculty comparisons. For the qualitative component (n = 30 staff), the sample size was guided by data saturation principles, ensuring that diverse perspectives were captured without redundancy.

Data measurement/sources

Data were collected using two primary instruments:
Structured questionnaires for students and lecturers, designed to assess the presence, depth, and relevance of climate change content in the curriculum.
Semi-structured interview guides were used with academic staff to explore pedagogical practices, faculty-level strategies, and institutional challenges in integrating climate education.
Questionnaire items included closed-ended Likert scale questions and a few open-ended questions. Instruments were pre-tested for clarity and content validity before administration.

Statistical analysis

Quantitative data from the structured questionnaires were analysed using descriptive statistics (frequencies and percentages) and cross-tabulations to compare responses across faculties. Missing data were handled using pairwise deletion to preserve the integrity of each analysis.
Qualitative data from interviews were thematically analysed following Braun and Clarke's (2006) six-step framework. Emerging themes were coded manually and verified by an independent coder to ensure credibility and consistency.

Ethical consideration

Ethical clearance was obtained from the Mangosuthu University of Technology Research Ethics Committee before the commencement of the study. Approval was granted on 11 February 2022, and data collection was authorised between March 2022 and April 2024. Participation was voluntary, with informed consent obtained from all respondents. Confidentiality and anonymity were maintained throughout the research process.

Results

Participant flow (Quantitative)

Table 1: participant flow (quantitative study)

Stage	Number
Students approached	150
Students potentially eligible	120
Students included	112
Students analysed	109

Table 2: Demographic characteristics of quantitative study participants (Students)

Characteristic	Value
Gender (Male)	45 (50%)
Gender (Female)	45 (50%)
Age (Mean ± SD)	22.5 ± 1.2 years
Faculty: Applied Science & Health	30 (33.3%)
Faculty: Engineering	30 (33.3%)
Faculty: Management Sciences	30 (33.3%)

Table 3: Demographic characteristics of qualitative study participants (Staff)

Characteristic	Value
Gender (Male)	18 (60%)
Gender (Female)	12 (40%)

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Age (Mean ± SD)	42.3 ± 5.8 years
Faculty: Applied Science & Health	10 (33.3%)
Faculty: Engineering	10 (33.3%)
Faculty: Management Sciences	10 (33.3%)

Table 4: Qualitative data themes and codes

Theme	Codes (n)
Institutional barriers	5
Pedagogical challenges	4
Interdisciplinary gaps	3
Student demand for action-oriented learning	4

Figure 1 illustrates the extent to which climate change education (CCE) has been integrated across three university faculties: Applied Science and Health, Management Sciences, and Engineering. The results show a significant disparity in integration levels among the faculties. The Faculty of Applied Science and Health demonstrates the highest level of CCE integration, with 89% of respondents indicating that climate change content is incorporated into their curriculum. This suggests a strong alignment between environmental awareness and the applied scientific disciplines, which often engage directly with ecological and health-related issues. In contrast, the Faculty of Management Sciences reflects the lowest level of integration at just 33%, indicating that climate change education remains marginal in business and economic studies. This gap raises concerns, given the critical role those future managers and policymakers play in driving sustainable development and climate action. Meanwhile, the Faculty of Engineering shows a moderate integration level at 64%, suggesting growing recognition of climate issues within technical and infrastructure-oriented programs, but still leaving room for further curricular enhancement.

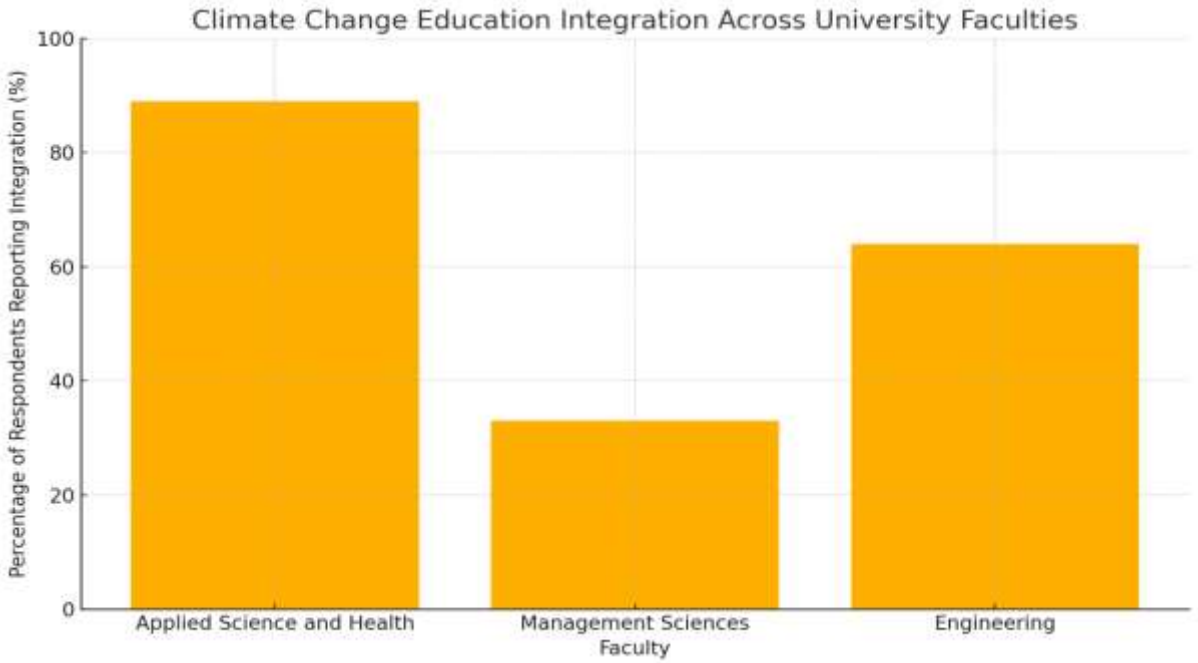

Figure 1: The graph showing the level of climate change education integration across the three faculties: Applied science and health, management sciences, and engineering.

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Discussion

The graph underscores a clear disparity in the integration of climate change education (CCE) across the three faculties surveyed, Applied Science and Health (89%), Engineering (64%), and Management Sciences (33%). These results reveal a concerning trend: while science-aligned faculties are advancing in climate literacy, others, particularly Management Sciences, lag significantly behind. This uneven integration presents a risk to producing well-rounded, climate-literate graduates across disciplines. Compared to other universities, these findings are not unique. A study by Leal Filho et al. (2019) across 43 universities globally found that climate change education is predominantly concentrated within environmental science and health programs, with limited representation in faculties such as business, law, and humanities. Similarly, Anderson (2012) notes that while engineering programs have begun incorporating climate risk and sustainability, these efforts are often fragmented and vary by institution. The moderate 64% integration in Engineering in this study is reflective of that global inconsistency.

In South Africa, a study conducted by Manteaw (2012) reported that many higher education institutions include climate change in sustainability discourse, but its integration across faculties remains weak, particularly in commerce-related disciplines. The low level of CCE in Management Sciences (33%) observed in this study mirrors that trend, emphasizing that business schools are not yet equipping graduates with the knowledge to lead in low-carbon economies or adapt to climate-driven economic transitions. By contrast, institutions like the University of Cape Town and Rhodes University have initiated interdisciplinary programs and sustainability-focused modules that embed climate content in broader academic offerings. These models illustrate best practices in holistic integration, offering a roadmap for other universities to follow. Therefore, the results from this graph, when compared with both local and global studies, highlight a systemic issue in climate education: the tendency to silo climate knowledge within traditionally "environmental" faculties. Addressing this gap requires transformative curriculum reform and institutional leadership that recognizes the universality of climate change and its relevance to all academic and professional fields.

Generalizability

While the findings provide valuable insights into discipline-specific CCE integration, they may not fully represent the state of climate change education in all South African universities or internationally. However, the trends observed, particularly the stronger integration in science-based faculties and weaker uptake in commerce-related disciplines, are consistent with findings from other institutions globally. As such, the results are moderately generalisable and offer a useful reference point for universities seeking to assess and improve their own climate education practices.

Conclusion

This study reveals that the integration of climate change education (CCE) across university faculties is inconsistent and discipline-dependent. The Faculty of Applied Science and Health demonstrated strong integration, while Engineering showed moderate progress, and Management Sciences lagged significantly. These disparities suggest that although some academic programs are preparing students to address climate-related challenges, others are not, potentially undermining the broader institutional mission of sustainability and climate resilience. The lack of interdisciplinary approaches and limited inclusion of CCE in core curricula reduces the effectiveness of higher education institutions in producing climate-literate graduates.

Limitations

This study was limited to three faculties within a single university, which restricts the scope of generalization across the broader higher education sector. Additionally, the data relied on self-reported perceptions from lecturers and students, which may introduce response bias. Furthermore, the study did not assess actual learning outcomes or student performance in climate-related modules.

Recommendations

To effectively integrate Climate Change Education (CCE) into higher education, universities should develop comprehensive institutional frameworks that embed climate literacy across all faculties, not just those traditionally aligned with environmental science. This requires a commitment to curriculum reform, particularly within faculties such as Management Sciences, to

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incorporate relevant content on sustainable finance, green entrepreneurship, and climate risk management.

Additionally, academic staff must be supported through ongoing professional development initiatives aimed at enhancing their ability to deliver interdisciplinary climate content using innovative and contextually appropriate pedagogical approaches.

Interdisciplinary collaboration should be promoted through shared modules, joint research projects, and cross-faculty seminars to encourage holistic understanding and problem-solving. Equally important is the active engagement of students through co-curricular and extracurricular initiatives, such as climate action clubs, student-led research, and sustainability campaigns, which help build practical competencies, foster civic responsibility, and prepare graduates to address climate challenges in diverse professional and community settings.

Biography

Dr. Sibonelo Thanda Mbanjwa is a dedicated lecturer in the Department of Nature Conservation at Mangosuthu University of Technology (MUT), South Africa. He holds a Ph.D. in Environmental Science and specializes in biodiversity conservation, sustainable development, and environmental education. Dr. Mbanjwa is deeply committed to community engagement, student mentorship, and the integration of indigenous knowledge systems into conservation practices. His work bridges academia and practical application, empowering students and communities through innovative teaching, research, and outreach initiatives.

Acknowledgements

I acknowledge the moral support and encouragement from the Deans and HOD of the Department of Nature Conservation, Faculty of Natural Science, Mangosuthu University of Technology.

List of abbreviations

UNFCCC - United Nations Framework Convention on Climate Change
CCE - Climate Change Education
UNESCO – United Nations Educational, Scientific, and Cultural Organization
MUT – Mangosuthu University of Technology

Funding

This work was not supported by any grant. The author did not receive research support from any company. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

I, the author, contributed to the study conception and design. Material preparation, data collection, and research were performed by Mbanjwa S.T. The first draft was written by Mbanjwa S.T.

Data availability

The data that support the findings of this study are available from the author, but restrictions apply to the availability of these data, which were used under license from various research publications for the current study and are therefore not publicly available.

Conflict of interest

The author declares no conflict of interest.

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Original Article

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PUBLISHER DETAILS

Student's Journal of Health Research (SJHR)
(ISSN 2709-9997) Online
(ISSN 3006-1059) Print
Category: Non-Governmental & Non-profit Organization
Email: studentsjournal2020@gmail.com
WhatsApp: +256 775 434 261
Location: Scholar's Summit Nakigalala, P. O. Box 701432, Entebbe Uganda, East Africa