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Global challenges, local responses: Exploring curriculum reform in South African engineering education

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Abstract

Background and Aim: There have been significant higher education curriculum reform initiatives over the past 30 years across different global regions in response to a range of drivers such as employability, global citizenship, and sustainability. In professions such as engineering, a key focus has been on holistic graduate attribute development for scarce skills needs in increasingly complex socio-technical sectors. This paper sets out to explore the drivers of engineering curriculum reform in higher education institutions (HEIs) in a Global South context.

Design/Method: Drawing on semi-structured, recorded focus group interviews with 28 program coordinators and academics across 15 of the 16 HEIs offering engineering qualifications in South Africa, the research team set out to determine what kinds of curriculum reform initiatives were being undertaken, who was responsible for initiating, implementing, and supporting these initiatives, and what were perceived to be challenges and successes. The emergent drivers were framed in relation to curriculum responsiveness theory analyzed using an overarching "critical realist" framework with structure, culture, and agency dimensions that systemically influence how curriculum reform is constrained or enabled.

Results: The findings reveal both internal and external drivers that align with economic, institutional, and pedagogical responsiveness. The dominance of some levers over others is influenced by the underlying structural and cultural dimensions that affect agency. While some institutions show agency in curriculum reform, the dominant structure–culture dynamic often constrains innovation and maintains the status quo.

Conclusion: The structure–culture–agency relationships that are presented highlight factors that constrain or enable curriculum reform, which has implications for practice and policy. To drive meaningful and sustainable reform, policymakers must develop frameworks that incentivize not only compliance with accreditation standards but also pedagogical innovation and social responsiveness, ensuring that curriculum transformation aligns with both economic demands and societal needs.

KEYWORDS
curriculum reform, drivers, Global South, responsiveness, structure–culture–agency relationship

1 | INTRODUCTION

Global shifts in higher education (HE) have seen significant curriculum reform over the past three decades in response to a range of contextual drivers (Gleeson et al., 2020; Howson & Kingsbury, 2023; Nordin & Sundberg, 2018). The increasingly globalized world and massification of student numbers have meant unprecedented numbers of school leavers entering tertiary education institutions from diverse backgrounds (Yates & Young, 2010). In science, technology, engineering and mathematics (STEM) fields, curriculum reform has additionally attempted to respond to both the dynamic technological evolution and a need to attract and retain potential professional graduates to address the wicked problems of the 21st-century world (Felder, 2012). The complex socio-technical and socioeconomic global challenges facing our STEM graduates—articulated as the sustainable development goals (SDGs)—have seen approaches to curriculum reform at multiple levels: macro (national/regional governance), meso (local/institutional/professional), and micro (faculty/department/program) (Moll, 2004). Across these levels, different contextual factors have contributed in various ways to approaches to curriculum reform.

Curriculum reform, often driven by global influence, is further shaped by national and regional politics and the pressures of social contexts (Gleeson et al., 2020). Actors within the curriculum space are typically then required to navigate these spaces while matching local needs and constraints (Nordin & Sundberg, 2018) as they attempt to prepare engineering professionals for their world of work. Context is particularly relevant when drawing comparisons between regions, defined based on disparities and inequality using the Brandt line, as belonging to either the Global North or the Global South (Lees, 2021). While the SDGs cover a range of global priorities, tension between economic growth and social justice is evident across these regions at different stages of development and is driven by national/regional politics and ideologies. In engineering, curriculum reform at a macro level has been orchestrated through global signatories to the international engineering accords designed to enable alignment, standardization, and mutual recognition of engineering qualifications that lead to professional registration in three categories: technician (Dublin Accord), technologist (Sydney Accord), and engineer (Washington Accord) (IEA, 2025). This macro-level professional reform initiative (top-down) has been supported by an evolving set of graduate competency profiles captured in the International Engineering Alliance (IEA) standards. All accord signatories, thus, have access to a set of standards that define what is expected of graduates at the three professional designation levels. The IEA profiles, together with signatory professional body qualification standards, are used to guide the design, implementation, and accreditation of engineering programs. These standards have emerged and evolved over the past two decades to reflect a more holistic view of what it means to be an engineering professional. A gradual shift from predominantly technical knowledge and skills has taken place over the past two decades to more refined descriptors capturing graduate "attributes," which include dispositions and practices such as self-regulated learning, ability to work in diverse teams, and greater awareness of the social, legal, environmental, and economic impact of engineering work (Wolff & van Breda, 2023). These shifting competency profiles, however, have different implications for engineering academics responsible for their integration into engineering programs in different contexts.

A major driver of curriculum reform in the Global North emerged as a result of the end of the so-called Cold War between the divided powers of the East and West, which saw the formal birth of the European Union in November 1993. With increased migration and mobility across Europe, the new economic and political union set about restructuring the HE system (the Bologna process) to allow for the alignment of different qualifications and mutual recognition (Kasuba & Ziliukas, 2004). The formalization of engineering education in the United States was originally driven by the need to develop specialized skills for agriculture and mechanization (Akera & Seely, 2015), with the American Society for Engineering Education (ASEE) officially serving as the "voice of engineering education" as of 1946. Multiple reform efforts reported by ASEE sought to respond to changing times and needs, with the dominant rhetoric post Cold War being the acceptance of "a neoliberal doctrine, manifested in attention to national competitiveness and … economic globalization" (Akera & Seely, 2015, p. 23). With the changing power dynamics between the East and the West in the Global North, the Global South similarly underwent significant changes. Emerging economies such as the then BRICS countries [Brazil, Russia, India, China, and South Africa (SA)—of which only Brazil is not a signatory to the accords] have demonstrated a predominantly economic orientation to educational reform. In SA, the focus of this paper, the first democratic elections of 1994 provided the impetus for economic reform and marked the end of the dominance of a minority White population over a majority Black population. The new SA had, as its mission, the desire to enable equitable access to all levels of education and, in so doing, access to economic participation (NPC, 2011). As a developing economy, in an era of unprecedented technological development, the country's HE institutions are simultaneously under significant pressure to address the needs of scarce technical skills. In all the regional global contexts—whether North, South, East, or West—signatories to the engineering accords see engineering departments facing a range of both external and internal pressures to reform curricula, which will enable the recruitment, retention, and success of graduates who are able to contribute to economic progress sustainably and ethically.

In the South African context, as in much of the Global South, meeting the challenge of education reform designed to address 21st-century needs is constrained by significant infrastructural, human, and technological resource availability (CHE, 2013). The education and training of graduates with the much-needed technological skills for economic progress and global competitiveness resides with post-secondary vocational and professional program educators, the majority of whom teach in large-class and poorly resourced contexts with increasingly diverse and ill-prepared cohorts. Although engineering programs across the country draw from the relatively elite pool of top achieving school leavers (based on mathematics and science admission scores), three decades since the dawn of the new SA, we are still grappling with poor retention and throughput rates on engineering programs (CHE, 2022; Fisher, 2011). Attempts to address these challenges have included increased national funding for academic capacity-building, with several international collaborative projects designed to enable engineering educators to review curricula, redesign pedagogical strategies, and engage in personal professional development. One such project is the “Transforming Systems through Partnerships – Innovative Engineering Curriculum” (IEC) project, co-funded by the Transforming Systems through Partnership Grant from the Royal Academy of Engineering (RAE) and the South African Department of Higher Education and Training (DHET) through their University Capacity Development Program (UCDP). The primary focus of these types of funding initiatives is to connect and grow partnerships that can lead to systemic, strategic, sustainable change. The IEC project specifically focuses on transforming the engineering education sector by adopting an integrated curriculum approach and identifying the support engineering academics need to effectively teach in these innovative programs.

The IEC project, a capacity-building collaboration between RAE, DHET, and the University College London (UCL), aligns with a global movement in engineering education that prioritizes skills, competencies, values, interdisciplinarity, inclusivity, digitization, and student-led learning. This transformation enables engineering graduates to become adaptable, socially conscious problem solvers, equipped to tackle complex global challenges. As engineering education shifts toward socially relevant, student-centered curricula, emerging leaders integrate these elements into cohesive educational experiences, moving beyond the traditional fragmented approach to curriculum design (Graham, 2018). A need for specific contextual case studies has been acknowledged to allow for broader theoretical generalizations (Nordin & Sundberg, 2018). Context matters for curriculum reform, not only in terms of the final curriculum design but also in relation to the process of transformational change associated with curriculum reform requirements (Case et al., 2016; Mitchell et al., 2021). Approaches to curriculum reform in engineering education are diverse (Christensen et al., 2015) and need to consider the unique contextual characteristics to ensure effectiveness, suitability, and sustainability.

This South African case study draws on findings from the IEC project. Collaborators on this project initiated a first-phase review of the engineering education reform landscape in SA, interviewing leadership and practitioners at 15 of the 16 higher education institutions (HEIs) offering engineering qualifications. This paper draws on the interview data and offers an exploratory analysis of engineering curriculum reform themes using an overarching structure–culture–agency (S-C-A; Archer, 2005) framework to understand the dynamics and tensions between structural, cultural, and agentic elements of the landscape. The study emerged from a desire to explore the current state of SA engineering education curriculum reform on the ground, given the structural shifts (which are common, globally), as well as three decades of curriculum change and capacity-building. More specifically, given problematic national statistics on retention, attrition, and throughput, the research team sought to probe, using the following research question: “What are the enabling/constraining drivers of engineering curriculum reform in the SA context?”

We believe that this case study offers an interesting and potentially informative opportunity for other regions in the Global South, as well as the Global North, that are grappling with the need to address diversity, equity, inclusion, and sustainability challenges in different developmental contexts.

2 | FRAMING ENGINEERING CURRICULUM REFORM

The critical realist (CR) concepts of structure, culture, and agency (S-C-A; Archer, 2005) have been used in several studies foregrounding the development of academics in education, as well as conditions for educational reform (Annala et al., 2023; Boughey, 2014; Coso Strong et al., 2023; Leibowitz et al., 2015; Ndebele & Maphosa, 2014). Archer's definition of "structure" revolves around patterns of behavior that are in response to the availability and distribution of material resources and forms of capital. Structural domains can be hierarchical, centralized, or integrated forms of the relations between agents and subsystems, which regulate the distribution of resources. The availability and distribution of material and human resources have implications for power relations, which manifest as recognizable social organizing structures. Social and governance service sectors such as banking, the legal profession, and educational systems have visible structural features, such as dedicated buildings, organizational structures, and protocols. Archer sees "culture" as the domain of ideas, values, and ideologies, which may be the causal result of the instantiation of a particular structure and the exercise of power, or—in contrast—culture is also considered as a "prime mover … [responsible for] … orchestrating the entire social structure" (Archer, 2005, p. 17). This chicken-and-egg analogy has implications for the concept of "agency," which refers to humans as individuals who are/(not) able to act voluntarily within a particular structure–culture domain. The three concepts of S-C-A are useful starting points for considering curriculum reform, given the social, academic, and professional structures within which curricula are enacted, the accompanying values (culture), and the potential for agency enabled by particular structures and cultures. An understanding of the underlying dynamics in a curriculum context enables an analysis of how drivers constrain or enable what happens in practice. It also enables inference of how different contexts and their associated priorities influence reform.

2.1 | The structures of reform

A review of the literature on curriculum reform at a global level reveals multiple themes which can be classified using Archer's concepts. At a macro level, the significant global shifts and economic alliances post the Cold War led to major reforms in European post-school education and training *structures*, with the attempted implementation of a 3 + 2 approach (Bachelor's + Master's) as part of the Bologna Process. This was intended to facilitate a *culture* of mutual qualification recognition and equivalence across the European signatories, but alignment has been a challenge for Washington Accord countries, for example, as a result of "significant differences in the definitions of credit hours versus the estimated hours of study" (Kasuba & Ziliukas, 2004). As in the Bologna process, the U.S.-led engineering accords are essentially quality assurance mechanisms for international benchmarking (Anwar & Richards, 2015). However, alignment, implementation of standards, and professional recognition differ significantly in different contexts. By way of example, the majority of U.S. state licensing boards do not acknowledge mutual recognition agreements, requiring non-state engineering graduates to undergo independent verification of their credentials and programs. Similarly, the 4-year Bachelor's in Engineering qualifications of European Washington accord signatories—the United Kingdom and Ireland—are explicitly excluded, with only the Master's in Engineering being recognized as equivalent to an accredited U.S. Bachelor's in Engineering degree.

The different qualification structures have implications for regions like Australasia, for example. While trying to develop compatible educational structures and cycles with its Asian counterparts—to allow for greater mobility, Australian engineering deans indicate that a 5-year engineering program as entry to the profession would better address falling entry standards and the emerging need for increased foundation-level studies (King, 2007). However, a 5-year program has implications for student financial burden (Scott & Yeld, 2008) and is challenged by employers who would prefer "higher levels of academic study to be taken after several years of practice" (King, 2007, p. 122). The Bologna Process and international engineering accord configurations are fundamentally structural initiatives designed to foster international mobility and globalization. While these intentions speak to an espoused culture of mutuality and global citizenship, they are essentially driven by economic need.

The economy as a key structural reform driver in engineering education—and the accompanying employability thrust—has made its way into educational practices. At the meso level, the United States has seen a significant shift to the adoption of competency-based education (CBE), with an increasing focus on better enabling the achievement of learning outcomes as opposed to the "traditional approaches that emphasize teaching processes and instructional delivery systems" (Nodine, 2016, p. 6). While this shift from teaching-centered to learning-centered approaches suggests a *cultural* swing, intended to empower students as *agents* capable of demonstrating mastery through more flexible and personalized instruction (Nodine, 2016), the rationale of CBE adoption is, in fact, a *structural* response to supply–demand dynamics. The pressure of increasing HE costs, in conjunction with the exponential development in technologies enabling online, hybrid, and flexible education approaches, has meant that more students can be served with fewer human resources (Nodine & Johnstone, 2015). As Kolmos et al. (2016, p. 391) point out, engineering curriculum reform is a response to "two main types of societal challenges …: the employability skills of graduates and the need for a sustainability approach to engineering." In this case, sustainability is often equated with efficiency of resource use. Similarly, structural reform of curricula to meet productivity (employability) targets and institutional or national competitiveness "depend on the ability to produce highly skilled and adaptive knowledge workers who can manage and manipulate knowledge and information and adjust to volatile and unpredictable global markets" (Ogude et al., 2005, p. 1).

2.2 | The culture and agents of reform

In attempting to "identify issues that impinge on curriculum decision making, including the consideration of professional engineering needs, the social and economic pressures, institutional parameters and student factors," Walkington (2002, p. 134) conceptualizes engineering curriculum reform principles necessary to guide a four-stage process. She further highlights that change begins with the structure and culture of the particular context, and requires "collaborative, informed decision-making, shared participation, sound management and appropriate support" (Walkington, 2002, p. 147). The culture of curriculum reform is described as responsiveness by Moll (2004)—the way the curriculum responds to economic (labour market), cultural (student body diversity), disciplinary (developments in knowledge production), and learning (pedagogical strategies that take the learner into account) factors. Building on this, Ogude et al. (2005, p. 7) see "the central determinants of curriculum responsiveness [as] being culture and identity" if the aim of HE is to promote peace and democracy "as the true foundation of sustainable human development" (Ogude et al., 2005, p. 7). Engineering education reform literature from the United States has long focused on changing cultures: from an insistence to be more responsive to student diversity and learning styles (Felder & Brent, 2005)—in which traditional modes of teaching are declared to violate "virtually every principle of effective instruction established by modern cognitive science and educational psychology" (Felder & Brent, 2005, p. 57)—to the seminal "two-paradigms" paper, in which Felder (2012) lists "chronic industry complaints about skill deficiencies in engineering graduates, high attrition rates of engineering students with good academic performance records, … and findings from both cognitive science and thousands of educational research studies" (Felder, 2012, p. 9) to call for a shift in the culture of engineering education.

Building on this ethic, a group of engineering education researchers (EERs) in the United States draw on an American Society for Engineering Education (ASEE) initiative to bridge the gap between the *what* and *how* of engineering education reform by engaging academics, chairs, and deans in discussion (Besterfield-Sacre et al., 2014). The authors note that change is a "factor of the combination of individual characteristics such as beliefs, values, and knowledge, and situational characteristics" (Besterfield-Sacre et al., 2014, p. 198). Here we see the synergistic relationship between structure, culture, and agency. In their extensive literature review, the authors highlight that faculty need to be partners in the change process. The analysis of their data saw two key themes emerging: the need for professional development and an incentivized or reward system for innovation. Through collaboration, academic development, and incentivized pedagogical innovation, a potentially shared vision can emerge (Besterfield-Sacre et al., 2014). Such a shared vision would signify a distinct curriculum reform culture. Jamieson and Lohmann (2012) echo the need for professional development and the building of sustainable collaborations to have a significant impact on student learning and performance. Walkington (2002) suggests that curriculum change can be facilitated by a core group of motivated academics who are appropriately skilled and practically able to meet. Such a group requires a coordinator with the time, authority, and skills to lead the change process. This suggests the need for a level of agency—despite the potential structure–culture constraints—in which engineering education scholars can take "strategic actions or perspectives toward professional goals that matter to oneself and goals that relate to impacting engineering education" (Coso Strong et al., 2023, p. 195).

2.3 | Framing the research problem in context

The holistic culture of reform is echoed in multiple global contexts. While initiatives demonstrating a shared vision of empowerment (culture) and involving faculty-wide collaborations (which may represent informal or formal structural configurations) are intended to empower educators (agents) both individually and collectively for the purpose of empowering their students, context always matters (Case et al., 2016; Leibowitz et al., 2015). In many instances, no matter where you are based, the education and training of engineers is seen as a national priority, often framed in terms of national economic progress. This is particularly true in emerging/developing economies such as SA, the focus of this paper. The South African National Development Plan (NDP) articulates its vision for the country in 2030 as one of "building an inclusive society, providing equal opportunities and helping all South Africans to realise their full potential, in particular those previously disadvantaged by apartheid policies, namely black people, women and people with disabilities" (NPC, 2011, p. 296). In terms of education, the NDP's vision is one of enabling equity of access *and* equity of success (Shay et al., 2016). Major educational structural shifts were initiated through the redesign of the National Qualifications Framework (NQF) to allow for different curricular pathways, with a specific focus on diagonal articulation across different qualification levels, intended to realize what is anecdotally known as a "street sweeper to doctor" philosophy. A new Higher Education Qualification sub-Framework (HEQsF) emerged in 2013 delineating different post-school qualification structures, purposes, and potential pathways. The publication of the HEQsF followed more than a decade of institutional mergers, linking a range of vocational, applied, technical, and research-intensive institutions across rural/urban boundaries (Leibowitz et al., 2015). Where the newly merged institutions had a mandate to provide qualifications beyond the third year of post-schooling, these were named comprehensive universities. In the engineering space, the renaming of the former technikons to universities of technology (UoT) provided an aspirational impetus: practice-based, vocational, and technical training qualifications began to demonstrate academic drift (Gamble, 2013), where increasingly theoretical subject matter was introduced into curricula to strengthen the "know why" knowledge base that many social realists were warning was necessary in the face of exponential technological development and information availability (Wheelahan, 2009; Winch, 2016; Young & Muller, 2014). With engineering industries bemoaning the shortage of scarce skills and the national mandate to support economic progress in the face of high levels of unemployment, by 2024, we are witnessing all institutions grappling with the tensions of strengthening the knowledge base (more theory) and simultaneously aiming to achieve graduate employability (more practice) (Gamble, 2013).

The concept of curriculum reform emerged initially in response to the creation of the UoTs and comprehensive universities, with dedicated government funding to support the redesign of qualifications aligned to the new HEQsF. Against these major HE structural shifts in the country, the period of reform saw the emergence of program and curriculum reform advisors located in centralized teaching and learning or curriculum development units. Many of these agents hailed from the literacies and academic support units initially set up for student support as institutions significantly increased their enrolments, particularly for previously disadvantaged and first-generation students, and the HE system began to massify (Morrow, 2009; Quinn & Vorster, 2019; Scott, 2009). However, 30 years after the birth of the new democratic SA, there are still high attrition and low throughput levels, particularly in STEM (Paideya & Bengesai, 2021), and historically pervasive patterns of racial inequality (Leibowitz et al., 2015; Salmi & D'Addio, 2021).

The challenges of curriculum reform or responsiveness have been debated in a South African context. Ogude et al. (2005, p. 3) reference the work of Moll (2004) who, "... cautions against reducing curriculum responsiveness to its economic dimension, namely an exclusive focus on responding to labour market requirements and preparing students for the world of work. Rather, he sees curriculum responsiveness as higher education programmes responding adequately to policy requirements and constraints, to the knowledge and disciplinary practices of higher learning and to the particular developmental and epistemic needs of individual students." Building on these ideas, Moll developed a stratified model of curriculum responsiveness that is contextually relevant to SA. The model was developed based on reflections emerging from a project that explored the challenges associated with curriculum responsiveness in South African contexts. The developed model delineates four distinct types of responsiveness including: economic and policy responsiveness, institutional/cultural responsiveness, disciplinary responsiveness, and pedagogical/learning responsiveness. Economic/policy responsiveness refers to curriculum orientation that is aligned to employability and producing graduates who can meet the needs of the economy. This type of responsiveness foregrounds the skills and knowledge including technology that is needed by employers in the labour market. Institutional/cultural responsiveness relates to the need to consider the social relevance and impact of curricula, developing knowledge, and students who are global citizens, and questions the social justice and ethical citizenship of the academic project. Disciplinary and pedagogical responsiveness focuses on the concepts, techniques, and practices of discipline-specific knowledge and skills and inducts students into the epistemic traditions of disciplines (Ogude et al., 2005). Pedagogical/learning responsiveness requires curricula that are sensitive to the diverse educational, social, and cultural backgrounds of students and how these enable or constrain access and learning. Moll's model acknowledges the tensions that exist between different drivers of curriculum reform and the potential impact of elevating some above others.

Engineering educators in the different institutional types (which offer programs designed to develop technicians, technologists, and engineers) have faced increasing pressures over the past three decades in their large, diverse, poorly resourced classroom contexts. While balancing their research–teaching–community engagement mandates, the national poor retention and throughput rates in STEM specifically have forced HEIs to pay attention to what is happening both in the classroom (pedagogy) and in institutional policies. The creation of teaching-focused senior management posts—such as Deputy Vice-Chancellors in the SA context—over the past two decades was intended to mark a distinct cultural shift: the recognition that "teaching and learning matters" despite the pervasive perception that it is really only primary disciplinary research that counts (Leibowitz et al., 2015). The shift in focus to matters of curriculum and pedagogy has seen multiple funded capacity-building initiatives in SA over the past 30 years. In partnership with government agencies such as the Department of Higher Education and Training (DHET), international organizations (such as the Royal Academy of Engineering) have enabled the collaboration of U.K. and local institutions on Existing Engineering Educator Staff Capacity Enhancement Projects (EEESCEPs) (Winberg et al., 2020). Over a dozen initiatives have seen master classes and workshops on project-based learning, teaching for employability, and developing professional skills (www.sasee.org.za/research).

3 | CONTEXT OF THE STUDY

The Innovative Engineering Curriculum (IEC) project [2020–2026] provides a context for this study. The IEC project comprises a team of dedicated engineering education practitioners and engineering education researchers across 10 SA engineering schools and the South African Society for Engineering Education (SASEE). Partnering with the University College London (UCL), the project's overarching goal is to develop a framework for implementing integrated engineering curricula that are relevant to the South African context. The collaborating team of volunteers aims to create a student-centered, contextually relevant, and integrated engineering curriculum, drawing lessons from the Integrated Engineering Programme at UCL (Mitchell et al., 2021), and to foster the professional development of engineering academics so as to be able to teach effectively within this innovative curriculum. The team facilitates national workshops and seminars that present approaches which combine technical skills development with authentic, holistic learning experiences that promote both technical and professional competence in students. There is also a significant focus on staff well-being, personal development, and community-of-practice (CoP; Lave & Wenger, 1991) building.

To implement the national CoP and capacity-building initiatives, the project initially entailed three phases, beginning with a review of the engineering education curriculum reform landscape. This paper reports on the first phase of the project, in which the project lead reached out to leadership at all 16 HEIs offering engineering programs to determine the engineering education curriculum reform landscape. A core research team (within the larger IEC team) interviewed leadership and practitioners at 15 of the 16 HEIs. The paper draws on the interview data of 28 participants across engineering institutional types.

4 | A PLURALIST METHODOLOGY

Initially, the CR concepts of S-C-A were not selected as an overarching theoretical framing for the project or the research design. Phase 1 of the project, rather, proceeded as an exploratory, inductive exercise in engaging with engineering academics and academic support staff to elicit and interrogate their personal experiences and perceptions of engineering curriculum reform in their contexts. A qualitative approach was chosen to collect rich data through guided discussion in online, recorded, semi-structured focus groups that allowed for reflective responses that could build on shared participant ideas (Bryman, 2016). It was only when collaboratively reviewing the interview transcripts and having participated in the focus group interviews and discussions that the researchers noted the tensions between drivers and agents of reform in the different HE contexts. The perception of bidirectional causality between particular kinds of structures and institutional cultures, as well as the concomitant impact on the agents charged with engineering curriculum reform, suggested that the S-A-A concepts would be useful to deductively tease out these relations. Furthermore, the accompanying literature review process on global curriculum reform foregrounded not only the use but also the usefulness of the concepts as exploratory and analytical tools. Methodologically, the paper presents the first inductive phase, describing the research methods and findings against the exploratory focus group questions, and then proceeds to a discussion using the CR framing, which is problematized at that point of the paper.

4.1 | Participant recruitment

The TSP-IEC project initially engaged with deans from various engineering schools across SA. During this engagement, the project's overview and objectives were presented and discussed to ensure alignment with ongoing curriculum reform efforts. Following this, the deans provided a list of their respective heads of departments (HoDs) or program coordinators (with some HoDs overseeing the program and others not). An email was sent to the corresponding dean and HoD or program coordinator for each engineering institution in SA. This invitation aimed to gather participants for small focus groups, given the project's overarching intention to facilitate CoP building. The participants were therefore purposively sampled (Cohen et al., 2011), and 28 individuals recommended as part of this recruitment process from 15 ($n = 16$) HEIs offering engineering participated in these focus group interviews. This group included representatives from six traditional (research-intensive) universities, three comprehensive institutions, and five universities of technology. The participants included HoDs, program coordinators, and other academic staff involved in curriculum renewal/reform activities. Participants received a Doodle poll to select available dates and were grouped together in pairs of two where possible, from different types of institutions and geographical regions. All focus group interviews took place online during July–December 2021 and were recorded and transcribed.

4.2 | Research protocol

A Powerpoint slide deck was prepared to guide each focus group interview. The session started with an introduction to the project and the intention to develop contextual understanding of what an integrated curriculum might be in SA. It also clarified the definition of an integrated curriculum as a student-centered, unified education approach that equally prioritizes both professional and technical competency development. The purpose of the focus group interviews was described as an opportunity to share current understandings of and practices in curriculum development and reform across the sector as part of Phase 1 of the broader project.

The semi-structured questioning was divided into three sections: curriculum reform practices, graduate employability, and going forward. For each section, the posed questions were placed on a slide that was shared with all participants. After reading the questions, participants were asked to share their ideas. In most interviews, participants shared their responses sequentially, but in some instances participants engaged and responded to each other's responses in a discussion format. The facilitator guided these discussions using prompts so that they stayed on topic. The questions shared with participants and used as a guiding frame for the interviews are included in Table 1. Although curriculum reform and curriculum renewal are often used interchangeably in research and practice, curriculum renewal is typically associated with continuous or incremental change while reform can be linked to radical change. To elicit experiences of all initiatives linked to curriculum change, the interview questions were phrased using renewal rather than reform.

The questions in Section 1 were designed to enable the team to have an overview of what the general curriculum renewal practices, initiatives, and drivers were at institutions and how curriculum renewal was perceived and experienced. The focus in Section 2 was to explore how curricula currently create space and opportunities to develop professional competencies and what an integrated curriculum approach might enable or challenge in the current space. Section 3 elicited any challenges and successes that participants had experienced or anticipated in relation to an integrated curriculum. This section was of particular interest to the research team, as it would aid the IEC project in designing Phase 2 of the overarching project.

4.3 | Data collection and positionality

Each focus group interview was conducted by a facilitator. Each of the facilitators was a member of the TSP-IEC team. To ensure consistency in facilitation, the first interview was conducted as a pilot. This pilot was recorded so that the facilitators could debrief after the focus group interview to align and adjust the approach as appropriate (Cohen et al., 2011). The three authors (constituting the research team and focus group facilitators for this phase) are all academics, one early-career, one mid-career, and one late-career. All three have experience in undergraduate engineering teaching, and other than the early-career academic, the other two have worked in engineering industries, one as an engineer and one teaching professional practice and communication in engineering. After working in industry, they both joined engineering departments where they became passionate about engineering education and student success.

TABLE 1 Focus group interview questions.

Section 1: Curriculum renewal	1. What are the curriculum renewal objectives? And why? 2. Who is responsible for implementation of the renewed curriculum activities? 3. What kind of support is available for these activities? 4. Are there incentives for academics to develop as educators?
Section 2: Employability—Integration of professional competencies	1. How are professional competencies taught in the curriculum? 2. Do you have any integrated learning activities (what/which year?) 3. Who is responsible for these modules/initiatives? 4. How do you measure/assess whether these professional competencies are achieved?
Section 3: Going forward	1. What are your key challenges and successes?

Driven by this interest, they completed PhDs in engineering education and are currently appointed in academic development positions, supporting engineering academics and leading student success initiatives. All three have collectively taught at the different SA institutional types. The early-career academic has a PhD in aeronautical engineering and has engaged in academic exchanges in the United States, European Union, and United Kingdom, where she has observed and experienced a variety of research and teaching practices. Her current role is coordination of community engagement and vertically integrated projects. All three authors share the similar motivation of implementing impactful initiatives to support SA's economic growth through quality graduates from engineering programs and have been collaborating for a period of 5 years.

The study adhered to ethical principles, and ethical clearance was obtained from the relevant institution.

4.4 | Data analysis

The transcribed data was captured into an Excel spreadsheet with a separate tab per interview using a unique label to anonymize participants. Data analysis was then conducted in two phases. First, inductive analysis was used to extract themes from the transcribed data using thematic coding to build logical arguments (Cohen et al., 2011). Each interview was coded by one research team member and then a second one. Emerging ideas were coded using phrases and colors, supported by highlighting quotes as evidence and the addition of personal notes (Merriam, 2009). Additional codes that were identified or suggested a contested interpretation were discussed among the research team until consensus was reached. All codes and researcher notes were captured in the spreadsheet with the transcribed data, clustering into initial topical categories in an iterative process (Merriam, 2009). The transcribed data could be linked to individuals during the coding process so that differences between institutions could be noted for interpretation. Once coding and analysis were completed, any identifying information that could link individuals or institutions to the findings was removed. The first phase of the analysis coded all transcribed data. The second phase of the data analysis focused only on data corresponding to the purpose of this study. Additional themes extracted from the data will be reported on in future publications.

The analysis process used a combination of computerized and manual techniques (Merriam, 2009). Once the initial database was completed, it was printed onto large sheets of paper where the codes could be used to discuss emergent themes. The larger TSP-IEC team regularly engages in developmental collaborative writing retreats, in the spirit of CoP building (Lave & Wenger, 1991). At one such retreat, the three researchers on this study shared the findings of the interviews and engaged in extended discussions around themes, interpretations, and observations using mapping on the printed pages. Effectively speaking, this broader collaborative engagement enabled a form of data analysis validation and alignment. It was at this writing retreat that the Moll framework and the S-C-A concepts were raised as useful tools to frame our findings.

The team felt that it was useful to map the emergent themes against the curriculum responsiveness categories of the Moll framework. The themes were first categorized as internal or external drivers, and then they were classified using the Moll categories. This mapping process enabled the team to visualize the nature of the drivers and made gaps more apparent. The mapping also revealed underlying tensions between different stakeholders in the landscape.

The emergent themes were then deductively analyzed using the S-C-A framing to unpack these tensions. This deductive analysis included re-reading through the database and coding instances of structural, cultural, or agentic factors. Each researcher then individually mapped and wrote personal notes on how they felt the S, C, and A tensions emerged. These individual reflections were then collectively shared, discussed, and debated. This approach therefore allowed the team to tackle the research question in a structured way using the Moll framework to identify the constraining and enabling drivers. The S-C-A framework was used to discuss how curriculum renewal is enacted and what mechanisms underpin it.

As the researchers are actors in the national context that this study explores, there is potential for bias. To address this, the positionality of the researchers has been included. To address internal validity concerns, the questions for the focus groups were revised based on expert feedback and a pilot focus group. The trustworthiness of the findings and their interpretation was addressed through adequate engagement with the data, the use of rich descriptions, and evidence to support claims (Creswell, 2012). The collective process of analysis allowed the researchers to challenge interpretations and raise alternate views (Merriam, 2009). Outlying or surprising data were also investigated through peer examination (Creswell, 2012) and literature (Cohen et al., 2011).

4.5 | Limitations

Although we try to capture a national picture, participant responses are influenced by their unique contextual factors that will influence how structure and culture influence individual agency. The national picture is therefore an aggregated summary of common themes and experiences. The study attempted to capture as much variation in experiences as possible by including participants from nearly all institutions across the spectrum of institution type. Although the purpose of this study is to interrogate a particular contextual landscape, and therefore the transferability of the findings to other contexts is cautioned, we hope that the focus in the discussion on these tensions and their impact is useful for contexts more broadly than this study.

5 | FINDINGS

In this section, the presented findings are centered around the initial themes that emerged from the coding process. The deductive analysis using the S-C-A framing is presented in the discussion section. To understand the national landscape of engineering curriculum reform, the themes that emerged from the conversations were categorized into external and internal drivers, as shown in Figure 1 where external refers to drivers outside of the HEIs and internal refers to those within. Furthermore, we classified the emerging drivers using Moll's categories of curriculum responsiveness (Moll, 2004). We combined the categories of economic/policy responsiveness with that of disciplinary responsiveness, as our investigations showed that in the engineering profession, these are intertwined.

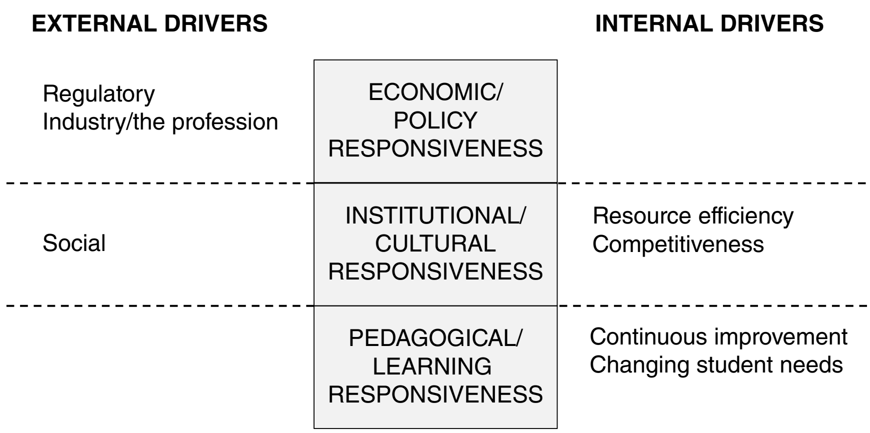

FIGURE 1 Identified drivers for curriculum renewal.

5.1 | External drivers

5.1.1 | Regulatory

This theme includes any external regulatory drivers, including those at a macro (national) level and a meso (professional) level. The most commonly referred to regulatory body referred to by the participants was the Engineering Council of South Africa, which governs the profession at a meso level. There was also some mention of the shift to outcome-based education (OBE) in the early 2000s and references to the changes in the HEQSF requirements with the introduction of a new 3-year Bachelor of Engineering Technology (BEngTech) qualification, indicating the influence of national regulations at a macro level. Participants also acknowledged the interplay between these two requirements of the profession and national standards. In general, these drivers are seen as constraints to innovation in curriculum reform, as expressed by this participant:

> And if you honestly ask me today to design an engineering curriculum, it will not really look like what we are doing now. It will be something where there are more integration with some of the other stuff that's being done. It will be something that ECSA will not necessarily be happy with because ECSA, and it's their job, it's not a major criticism, but they need to be able to tick off boxes to say, everybody adheres to this model. [11]

Although seen as constraining, participants generally agreed that compliance with these standards was a non-negotiable and that curriculum renewal is frequently driven by the need to comply:

> I think they are firstly initiatives taken by ECSA on which we have to react. [2]

and

> So we need to conform with the new changes from ECSA, which affected the way our curriculum was structured. [4]

Most of the focus was on the ECSA professional body standards and there was limited mention of the guiding national education standards, such as qualification level descriptors or guidelines produced by the Council on Higher Education.

5.1.2 | Industry and the profession

This theme includes responses to the labor market in terms of the needs of industry and the economy (economic responsiveness) and shifts in the discipline due to, among others, rapid evolution in technologies (disciplinary responsiveness). As mentioned earlier, we found it most suitable to combine Moll's categories of economic and disciplinary responsiveness for the engineering profession, as these are inherently linked.

Many participants touch upon the relevance in terms of technological advancements and the implications. This participant explained how the curriculum needs to consider and respond to these changes:

> But now, the complexity about the curriculum renewal comes in that, when a student starts to work, they will most probably not calculate bending beam diagrams by hand, they will press a button and the computer will give them the answer. [11]

Many participants focused most frequently on the technology and technical competencies associated with these:

> … I think we have an important job as engineering educationalists to make sure that the kind of stuff we teach, in other words the content, the "technessness" kind of stuff, keeps up to date and is relevant. [1]

> We've also just recently upgraded our simulated working environment, which is very much more in line with industry 4.0, we've got Cobots and a whole lot of automation processes. [3]

Simultaneously, it was expressed that curriculum design needs to consider the relevance of the skills that students will be obtaining, and, as a consequence, the benchmark for good development is against what industry needs as expressed by this participant:

> I think if we had to look, because it's a new program, we actually need to see if what we are teaching the students and what they then have developed the skills that they develop is actually what the industry needs. [14]

One of the participants reflected on the challenge regarding the ever-increasing demands from industry regarding what is expected from our graduates and the impact it has on students:

> We just keep on adding things to the module, but we're not taking anything out. And we're starting to see that our students are buckling under the strain. That is, it's really becoming problematic. So, industry wants more, but they don't want us to take anything out of our programs either. So it's this .... We're caught in a very difficult position. [3]

All accredited engineering programs require advisory boards, constituted by practicing engineers, that meet departmental leadership annually. As potentially the primary source of determining what industry needs, there were mixed descriptions of the value of these sessions:

> And then also working in a department, the advisory board, which sits at least once a year, discussing what's happening in industry and bringing what the needs are out there to the department. So based on those two input parameters, and I think the objective should rather be to have the curriculum really relevant to what's happening in industry. [5]

The previous quote also confirms the sentiment that industry relevance should be the driver of curriculum renewal.

In addition to advisory boards, some participants also discussed how they engage with early career graduates as key stakeholders in the ecosystem. Participants describe the value of collaborating with such stakeholders:

> ... and then we can have robust discussions surrounding the curriculum changes that are required, where the industry sees the field going, what changes that need to happen .... [3]

> And I think one of the key challenges is that we haven't been having that conversation with our students once they go up, and they're doing real stuff. And they're saying, "okay, that's great. You know, we did a lot of 1, 2, 3 years of chemistry, we don't need any of that, but we didn't do any finance management, and I have to do that every day." [1]

Although many comments spoke of relevance and integrating appropriate technologies in the curriculum, there were also references to new emerging specialization fields as the reason for curriculum renewal:

> So if we see the need to change things, we will, for example, maybe introducing more use of software programming in certain modules, or introducing new technical electives so students can decide to take an elective in, for example, waste management, or biorefining, or that kind of thing. [7]

One response to preparing graduates for unknown futures is to highlight the importance of fundamentals that may ensure a graduate's long-term relevance:

> We are educating students, so that over 20 or 30 years from now they can [work] from first principles, and that is the important thing, adapt and change. And still be relevant. [2]

Participants therefore highlight the balancing act that is required between introducing new content to ensuring that the fundamentals are in place to make graduates sufficiently versatile to respond to the ever-changing professional landscape. The need for a retained focus on appropriately developed fundamentals is described as:

> … although they just press a button, and they need to now understand how does the 'press the button part' work, they still need this basic fundamental knowledge of, Okay, if it looks like this, this is what it means. [11]

The ability the participant is referring to here is simultaneously demonstrating an understanding of the fundamentals and an ability to critically reflect or reason. This raises the question of the relevance of competencies beyond the technical. While most of the participants elaborate on technical and industrial relevance, one adopts a more holistic view:

> … the objective … is primarily to ensure that the standards of industry are being maintained … so that's the reasons why we have to, so also for the throughput and success and access, and to make sure that the curriculum is aligned to what we are actually wanting the students to be holistically developed critical thinkers, innovators, thinkers, as well. [15]

For the most part, however, participants focused on engineering curriculum renewal drivers as being industry and profession related from a predominantly technical perspective, with a strong focus on "content":

> And sometimes we do make interventions in either bringing in new material, obviously cutting material from the curriculum. So I think for us, the important thing is to actually stay relevant. [3]

5.1.3 | Social responsiveness

This external driver refers to responding to the needs of society. This relates to Moll's category of cultural responsiveness, which calls for a focus on social justice and includes adapting to the increasingly diverse heritage of the student body and what this means for different types of knowledge and approaches to curriculum design. It also concerns the tension between physical and epistemological access and success. This driver concerns the external pressures in this sphere that impact curricula. It was expected that this driver would have emerged more strongly from the data given a multitude of protests in SA calling for HEIs to respond to these exact societal needs (including decolonization) and a global focus on the SDGs. However, most of the participants focused on the logistics of the changing nature of the student body, referencing increasingly diverse and larger class sizes as both a driver and constraint:

> … and a large part of that was from the perspective of dealing with larger class sizes, dealing with more diverse and differently-abled student intakes, trying to assess kind of at an institutional level questions around transformation. [10]

There was one comment that indicated that curricula are renewed to enable students to "benefit society." The participant specifically focused on the development of entrepreneurial skills, which is a small subset of the impact of engineering activity on society—mainly with an employability ethos—shown by the participant's comment:

> … I see that as a success because they were taken out and a lot of new ones that fit into the system, that will make those students employable outside and be beneficial to society for example, there's a lot going on in entrepreneurship. [13]

It is not clear, however, from this quote what is meant by "beneficial to society"—it seems that this participant may be talking more about relevance for the workplace.

5.2 | Internal drivers

The external drivers are framed in this paper as those factors external to the institution that drive change and reactions within institutions. The internal drivers, in contrast, are those that the institution and faculty suggest arise from within the institution based on what matters to them. The relationship between the external and the internal drivers is evident in Figure 1 as internal drivers originate as institutions respond to external drivers.

5.2.1 | Reputation and competitiveness

This driver reflects the need to remain competitive as an institution and maintain a good reputation in the sector. Institutions compete to gain students for both undergraduate and postgraduate degrees, and reputation is seen as a key factor in winning this race. This desire is a driver for curriculum renewal and packaging of qualifications that aims to use the curriculum to attract students and build a profile for the university as a specialist in certain fields or approaches, as expressed by this participant:

> And to try and increase on our student numbers at undergrad level, we've been looking at exactly this curriculum renewal where we can make the civil engineering curriculum or the program, I think our Dean refers to it as being sexy, being … encouraging students to make it more … to be a field that students still want to study. [3]

5.2.2 | Resource efficiency/economies of scale

This theme includes curriculum responses that emerge because of internal institutional constraints. These include constrained availability of resources, including academic time, but also venue and laboratory space. The viability of programs was also cited as a driver of making changes to curricula to harness economies of scale and reduce duplication and overlap of content or work. One head of department articulated the multifaceted nature of resource-related constraints and the relationship to curriculum renewal:

> But if you start doing things more clever[ly], you can end up where you decrease your teaching load by being more clever …. It was also because of financial sustainability, where we started looking at modules, and realised that you've got a module of dynamics for mechanical engineers and dynamics for electrical engineers and dynamics for computer engineering students, and everybody's got a lecturer. [2]

Institutional constraints can also create a tension that potentially compromises curriculum needs, with curriculum renewal initiatives often shelved due to a lack of resources:

> But we've got finite resources. And the question is the needs, which needs are the biggest? And in my opinion, at our university, I mean, just look at our student staff ratio in my department … It's unhealthy, and therefore I cannot afford it, to actually take some of my money, and I put it somewhere, for somebody to manage something. [2]

5.2.3 | An ethic of continuous improvement

In several of the interviews, participants indicated that the process of curriculum renewal is part of an existing ethos of continuous improvement that strives to reflect on what is working and respond accordingly. These reflective activities appear to occur either as part of a formal process:

> So we continuously go back and assess what's working, we do evaluation, we have feedback sessions in our teaching and learning committee meetings as well. [15]

or in a more ad hoc manner, in response to a particular trigger:

> And many of my colleagues have had similar ideas … Well, not similar in the kind of embodiment but similar in the thinking that they're like, "okay, there's a gap here, what are the students battling with? Where could they? How could we think about these things differently?" [1]

Some participants specifically mentioned activities that relate to the alignment of course content across years:

> So better aligning what we are doing from year to year, so we have had curriculum renewal objectives that aim to better align what's happening in the year, that builds on the previous year, that builds on. [4]

Although some of these initiatives do appear to be taking place at a department and program level, they most primarily relate to incremental change.

5.2.4 | Changing student needs

This driver also concerns cultural responsiveness, but the pressure is being felt from within institutions. The most prominent internal driver for participants appeared to be responsiveness to changing student needs and characteristics. The marked increase in student numbers and diversity has seen poor student success rates and retention. Student needs were observed by academics both during teaching and learning activities or were specifically sought from students through direct engagement:

> So we are very mindful to have student body meetings ongoing as well. [15]

Some lecturers expressed a need to do something, expressed more as a frustration emerging from identifying aspects of the curriculum that were not working.

> … there is also this idea among students that once you're in the program, you're entitled to pass at some stage at least, and some of the challenges that we experienced is that there is, in a sense, too much leniency in readmitting students, for example, that don't perform. [8]

There was an acknowledgement that students enter the institution with different backgrounds and from a variety of contexts. It was suggested by some that this diversity affects the preparedness of students for the expectations of the qualification:

> Of course, there will always be challenges. But, you know, because some situations where, from both local and global perspectives, the challenge we experience mostly is that students, most seem to be unprepared either from the initial foundation, you know, high school. [16]

Participants also presented a sensitivity to considering how the curriculum and curriculum change affect students from different contexts. Curriculum considerations included individualizing curriculum experiences to adapt to the pace and way in which individual students learn:

> Challenges for me would be that pupils are different, students are different. So my wish would have been to have almost a core curriculum, or course curriculum, which assist each student in his own, the way they each individually learn, and can learn. [11]

And how the accepted socially constructed mechanisms for teaching, learning, and engagement may or may not resonate with students from different backgrounds and contexts:

> … I think one of the difficulties was is actually engaging with students because of different culture, and the culture was you don't ask questions, you don't look an elder in their eye, etc. [3]

Much of the participant discussion focused on accommodating student diversity from a language, culture, race, and background perspective, or meeting them closer to where they are. One participant also reflected upon the purpose of curriculum renewal and questioned on a more fundamental level who benefits from curriculum renewal initiatives.

> If you make this change, who benefits and how does this affect students from disadvantaged backgrounds? [10]

5.2.5 | Reform responsibility

Although not a driver in itself, the question of responsibility for engineering curriculum reform provides insights into the question of constraints and enablements, which will be discussed in the next section. The responsibility for curriculum reform, for the most part, resides with heads of departments and their various program coordinators. Ultimately, the deans are responsible for all programs in terms of professional body accreditation cycles and alignment with institutional mandates. However, many participants indicated that despite perceived top-down constraints placed on curriculum change, individuals are often inspired to drive change from the bottom up. It appears that although there is a lack of formal mechanisms to initiate and facilitate this, there is flexibility and space for some change. Individuals often initiate change driven by personal interests or a passion to make a difference:

> But I find that people are actually mostly internally motivated, you know, to make a difference in students lives and to be presenting things that's relevant and to stay current and… our lectures are quite connected also to industry through various, you know, either research projects or consulting work and so forth. [4]

For individuals who take initiative, there are mechanisms for recognition and support:

> So, you know, actually I think the internal motivation is higher than the promotion, but people want, they want to have external recognition as well. So it's a good thing. We are very pertinently recognizing contributions on curriculum development level and in teaching as well. [4]

and

> If you show initiative, then you do get support. [15]

Because of the individualized and ad hoc nature of this form of curriculum renewal, individuals are often alone in these initiatives. As a result, academics seek out opportunities for collaboration and support, which is often done outside of their departments. This enables individuals to create communities-of-practice but also encourages broader and cross-disciplinary thinking and collaboration:

> … that extended collaborative approach and guiding our students not just to be stuck within the engineering faculty, but we [are] creating that holistic development and also that extension of reaching out […] partnering with our sister institutions, or our sister practices and departments to afford that support. [15]

Some reform initiatives also see the use of academic development practitioners from centralized units such as teaching and learning or curriculum centers. In some cases, this is perceived to be unsuccessful and there is no clear connection point or benefit:

> For the most part, these external consultants/advisors struggle with understanding the contents, because they come in with their own pedagogy styles and different ways of doing, and different ways of knowing. [8]

Where relationships have been built between departments and such advisors, this collaboration is perceived as beneficial and normal.

... is our academic development practitioner. So she works quite closely with the HoDs, from the various engineering departments in terms of anything from a teaching and learning perspective, and from a curriculum perspective. [9]

6 | DISCUSSION

To address the research question, "What are the enabling/constraining drivers of engineering curriculum reform in the SA context ?," we mapped emergent driver themes using the Moll curriculum responsiveness framework.

We found two dominant external drivers. Many curriculum renewal initiatives in departments are driven by the regulatory body. This is similar to other contexts (Gleeson et al., 2020), although in this context there is an underlying sense that the requirements constrain innovation. More prominently, curriculum renewal is driven by employability and the profession. This is enacted through advances in technology or direct engagement with industry, which shapes the content of curricula. Employability is a recurring theme in global studies (Kolmos et al., 2016; Yates & Young, 2010). In the literature, employability is often coupled with economic development (Moll, 2004; Yates & Young, 2010); however; in this study, conversations around the economic and professional drivers did not discuss the implications that this would have on local economic development. This could suggest that these drivers are responding in a reactive rather than proactive manner, "pushed" by the demands of stakeholders rather than "pulled" in response to local needs.

This is perhaps emphasized by the less prevalent social driver theme. As mentioned in the findings, it was somewhat surprising that this was not more prevalent in the participant responses given the local socioeconomic and socio-technical challenges. Globally, there are also increasing calls for curricula that focus on sustainability and the SDGs (Kolmos et al., 2016), although even globally the focus tends to be on the environment and less on broader social impact (Watson et al., 2013).

The emergent drivers were overwhelmingly internal, perhaps suggesting that these draw attention away from what is happening externally. Participants mentioned competitiveness, a driver also mentioned in international literature (Gleeson et al., 2020), and associated focus on resource efficiency. In many instances, renewal appears to be driven by individuals making changes to underlying pedagogical practices (Howson & Kingsbury, 2023) or addressing issues of overcrowded curricula (Mulder et al., 2012), which then gains momentum to influence more large-scale renewal initiatives.

Perhaps most relevant for a project that aims to develop more holistic and integrated curricula, it was interesting to note that although curriculum renewal is taking place, it is most frequently the technical content or the way in which this technical content is taught that is being adapted. There is an underlying sense that there is a trade-off between technical and professional competencies (Eidenskog et al., 2023) and that developing professional competencies occurs at the expense of technical competencies. This has implications for broadening curricula to develop graduates who can tackle the grand challenges of society where simultaneous development of professional and technical competencies is suggested (Tryggvason et al., 2001) while concurrently addressing the social and attitudinal aspects (Lozano & Lozano, 2013) of a student's development.

It is evident from the analysis of the emergent themes that there are underlying tensions that influence what draws academics' attention, time, and effort and that individual and collective actions are often pulled reactively rather than proactively in the curriculum renewal space.

To explore these tensions further, we explored how curriculum reform is enacted and what mechanisms underpin curriculum reform. Each of the drivers suggested particular structural configurations, and the participant interviews offered perceptions of their impact. The observation by the research team that despite the similarities in structural features of the different HEI contexts, there appeared to be a different "culture" in the different spaces and different individual responses, which raised the question of whether or not the CR concepts of S-C-A might not be a useful way to re-examine the data. In a study on student agency using these concepts, Luckett and Luckett (2009) clarify the Archerian concept of structure as possessing "generative powers of constraint or enablement", which are not necessarily deterministic. A subjective agent, confronted by a particular structure, and who reflexively deliberates through internal conversations can "decide how to respond or react to objective circumstances that are not of their own making" (Luckett & Luckett, 2009, p. 471). Leibowitz et al. (2015) establish in their study on academic development that all entities have structural and cultural properties, and that it is "how they interplay with … human agency that leads to the variability of outcome" (p. 318). Given the contextual nuances in the data, the research team set about examining the potential structural and cultural features of the listed drivers (Figure 2) with a view to interrogating the implications for agency. The emergent themes and discussion using the Moll framework allowed us to determine the enabling and constraining drivers of curriculum renewal in the SA context. By interrogating the underlying S-C-A dynamics, we were further able to understand how curriculum renewal is enacted and what mechanisms underpin this. The external drivers were interpreted as primarily structural elements. The regulatory and industry drivers were seen as structural because of the way in which these prescribe to a greater or lesser extent how curricula are designed. In SA, owing to the historical context and political pressures to address the inequalities of the past and the current social and economic challenges, social drivers are also seen as structural elements, as these influence policy in relation to HEIs. Internally to institutions, the cultural and individual agentic elements emerge. We have characterized the influence of individuals as agentic drivers as we noticed how agents can be strong drivers of change.

6.1 | Structure–culture dynamics

In some contexts, the regulatory and professional environment seemed to offer a useful framing for what needed to happen in the curriculum. The new/revised qualification standards—aligned to international standards—provide a structured framework toward which academics can work in preparing graduates for the profession. These standards and the accompanying regulatory and accreditation processes are all highly structured, and demand compliance for departments to retain their right to educate engineers. Indeed, a culture of compliance was dominant in the data. In contrast, the available resources (human, infrastructural, and financial) consistently emerged as structural constraints. These resources are structural in that they aid in the management and circulation of the required materials and opportunities to reform curricula and constrain what is possible in rethinking how engineering curricula could be structured differently. The impermanence of contract support staff, for example, has long been cited as a reason for the failure of our institutions to engage in meaningful reform (Shay, 2012). These are staff appointed by centralized teaching and learning divisions, often funded by short-term university grants. A second resource-related structural issue is the question of massification in student numbers, as new SA generations were afforded the opportunity (and government funding) to engage in higher education study, but the majority being without adequate primary and secondary schooling, and effectively "structurally disadvantaged" (Luckett, 2009). The need for concerted foundational provision (CHE, 2013; Scott, 2009) saw the structured rollout of special funding for a foundational year in addition to the mainstream qualification. However, these structural attempts at HE reform have failed to significantly retain students and enable sustainable graduation rates. This has emerged as a significant constraint, manifesting as frustration on the part of several participants. Where staff regularly teach classes numbering in the 100s, a desired culture of "care" becomes one of burnout and excessive workload. The increasingly constrained resources that emerge also influence internal cultures and decision making that favor economies of scale and viability and competitiveness and reputation as institutions are forced to fight over smaller pieces of "resource-pies" such as the best students, funding, and access to resources.

The structured national regulatory framework—while intended to address the unequal distribution of resources and redress human rights atrocities under Apartheid—is intended to enable a culture of transformation. In this study, however, the lack of engagement with national educational policies suggests that the regulatory requirements of the profession are held to be of primary value, possibly perpetuating the traditional culture of primarily legitimating knowledge and technical skills. This traditional technicist culture is reinforced through the pressure to align curricula to relevant industry needs, and there is agreement across the sector that curricula have become bloated in attempts to remain competitive. While the formal literature on industry needs has evolved over the past three decades to tackle the challenge of professional skills development through innovative pedagogies, there remains a pervasive sense that these are "soft skills," external to the core curriculum. With such a strong focus on the prescribed natural and engineering science content, along with associated technical knowledge practices, a culture of "meeting standardized specifications" emerges as one of uninterrogated compliance.

6.2 | Culture–agency dynamics

Within a predominantly compliance-oriented culture, agents are necessarily responsive to top-down pressures to interpret, apply, and maintain teaching and assessment practices that meet the regulatory standards. These agents are both departmental leadership and the lowliest of junior lecturers. Archer defines reflexivity as a necessary precondition for the development of agency. When agents consider themselves in relation to their social context (2007), they are ostensibly able to

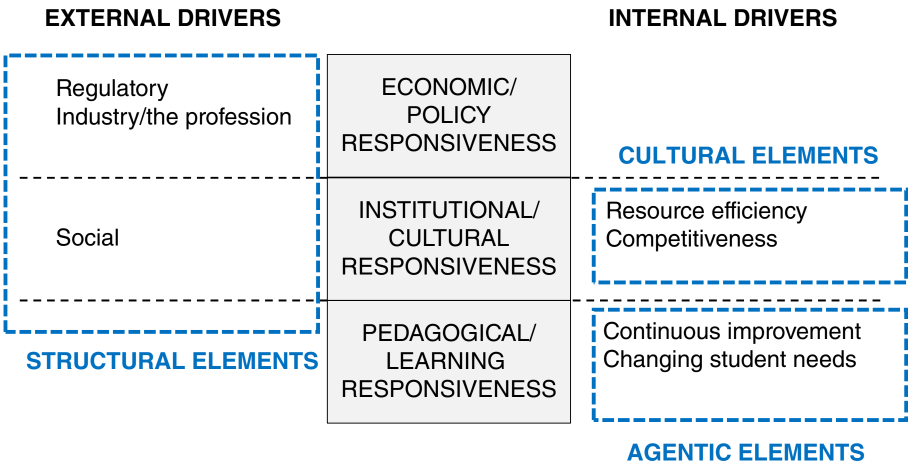

FIGURE 2 Structural, cultural, and agentic features of curriculum renewal drivers.

choose a course of action. In this paper, we suggest that the reflexive consideration of social context for the majority of agents is overwhelmingly constraining, which has implications for facilitating CoP development (Lave & Wenger, 1991). Where agents are identified as being particularly resourceful or successful, we observe a culture of "care," the desire to change their students' lives in a socially responsive manner. Under this category in the original analysis, we note that some participants indicated that an existing culture of continuous improvement has driven curriculum reform dedicated to responding appropriately to increasingly diverse cohorts. This cultural shift is supported by the availability of dedicated academic support staff—a structural enabler, representing pedagogical responsiveness (Moll, 2004).

6.3 | Structure–culture–agency dynamics

Across the data, participants see regulatory structures as constraints or enablers of their personal agency: rules within which they operate. By extension, where regulations (structures) are spoken about in departments in a way that emphasizes the rules—which influence decision making, a culture of traditionalism is evident. In some cases, agents use these regulatory structures as "excuses" for not changing or as justification for the way in which they do things. Although it may appear that the structure deterministically "drives" the behavior, there is also the observation that a collective culture emerges from and perpetuates powerful structures. Agents within such environments have little choice but to maintain the status quo.

As much as one would like to claim that agency is not as deterministically linked to dominant structure–culture configurations, it seems clear in the data—to quote one participant—that the biggest challenge is "time and effort. You know, our staff are really overworked and are tired and it's exacerbated right now. Everybody's burnt out, I can feel it, my eyes are gonna fall out" [1].

7 | CONCLUSIONS

The intention of this paper was to understand the current landscape of curriculum reform in engineering education in SA. The study used focus group interviews with participants across engineering institutions to explore personal experiences and perceptions that probed the drivers for reform and how this reform takes place. Participant responses were analyzed to identify drivers of curriculum reform and who initiates and enacts change and with what support. An analysis of the data revealed several drivers that were mapped to highlight both internal and external drivers, which were further categorized into responsiveness types. By analyzing the drivers in relation to the process of change, relationships and tensions between the drivers were revealed. It became apparent that there were structural, cultural, and agentic elements that facilitated or constrained curriculum reform, which warranted further exploration. The study continued to discuss these S-A-C relationships to understand the mechanisms for curriculum reform in particular contexts.

The structures present in engineering departments in HEIs are built around the need to comply with professional body regulations and are constrained by structural societal issues. These structures both drive and constrain decision making. They generally manifest in a centralized hierarchical manner that enforces compliance to protect reputation and the license to operate. From these structures emerges institutional and departmental cultures that are represented by the collective values, ideologies, and ideas. These are typically rooted in resource efficiency and competitiveness, predominantly in response to employability demands. Although responsiveness to the ultimate employers is important, the weight of economic responsiveness over social responsiveness is evident. This raises questions around who benefits from the system, that is, society, individuals, the country, or the economy, and to what end. The cultures within departments can once again constrain or enable individual agency. The agents within the system are those most able to enact change through continuous improvement of activities and responding to student needs. Agents can feel supported and encouraged to do this or overwhelmed and frustrated by their inability to make a difference. Although many individuals are "lone" agents, connecting or building communities of agents can start to influence culture and challenge structures. One could argue that change and true responsiveness need disruptions along the S-A-C continuum. True curriculum reform that is able to effectively start to drive transformational change does, however, require these disruptions to propagate along the continuum because of the highlighted relationships. A chicken-and-egg analogy probably best describes where these disruptions should ideally start—with different contexts providing unique scenarios and potential.

The S-A-C lens elicits a holistic view of what could be required to drive meaningful and sustainable curriculum reform and responsiveness in engineering education. Emulating the views of Henderson et al. (2011), which call for *disseminating curriculum and pedagogy, developing reflective teachers, enacting policy, and developing shared vision*, we believe that through collaboration across institutions, as well as systemic academic development and pedagogical innovation, a shared vision can emerge. Engineering education reform needs to be woven across the S-A-C continuum, with incentives for engagement and the creation of spaces to question, reflect, experiment, and fail (Besterfield-Sacre et al., 2014).

8 | IMPLICATIONS

While this study focuses on South African engineering education, the findings have broader implications for regions where curriculum reform is shaped by structural constraints, economic drivers, and professional body regulations. Many countries in the Global South and Global North grapple with similar tensions, where accreditation and employability concerns often outweigh social responsiveness in curriculum decision making. The hierarchical and compliance-driven structures observed in South African institutions may resonate with those in other developing economies, making the S-A-C model a valuable framework for international curriculum analysis.

To drive meaningful and sustainable reform, policymakers must develop frameworks that incentivize not only compliance with accreditation standards but also pedagogical innovation and social responsiveness. This shift would encourage educators and institutions to engage in transformative curriculum practices that align with both economic demands and societal needs.

Additionally, collaborative networks between institutions across regions can serve as platforms to exchange models of reform, particularly in contexts where higher education is shaped by colonial legacies, regulatory compliance pressures, and industry-driven demands. Comparative research could further explore how different regional accreditation frameworks either enable or constrain transformative engineering education, offering valuable insights for policymakers and educators seeking to balance global standards with local realities.

Mitchell et al. (2021) describe the change of curriculum reform as taking place at three systemic levels: the individual level, the organization level, and where the two integrate and interact. The S-C-A analysis confirms this framing and highlights the importance of broad stakeholder engagement (Walkington, 2002), collaboration (Jamieson & Lohmann, 2012), and developing communities-of-practice (Wenger, 2000) when tackling curriculum reform. This facilitates the building of educator agency (Annala et al., 2023; Jamieson & Lohmann, 2012), particularly if supported with professional development (Besterfield-Sacre et al., 2014; Caratozzolo & Membrillo-Hernández, 2021; Dai et al., 2023) and incentivization (Besterfield-Sacre et al., 2014).

The IEC project has integrated many of the findings from this study by developing consistent cross-institutional and regional communities-of-practice through online and in-person events. Through these, we have included and invited stakeholders (researchers, accreditation agents, societies, and institutional champions) into strategic planning sessions across the sector: we have influenced policy change and developed workshops to engage meaningfully with the policy changes, created programs to support academic staff and change agents to have the capacity to engage with the change, and integrated transformative teaching practices. The project drives the changes as a bottom-up approach, connecting stakeholders and change agents strategically to ensure there is a collective voice that can speak back to the culture and the structures that keep institutions and academics stuck.

The study also prompts educators to consider who benefits from curriculum reform and where the individual students and broader society are in this space. The study revealed a lack of external forces driving the social responsiveness agenda and the strength of economic and policy responsiveness. We believe that this warrants further study, which includes the perceptions of broader stakeholders, such as policymakers, students, and industry partners.

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