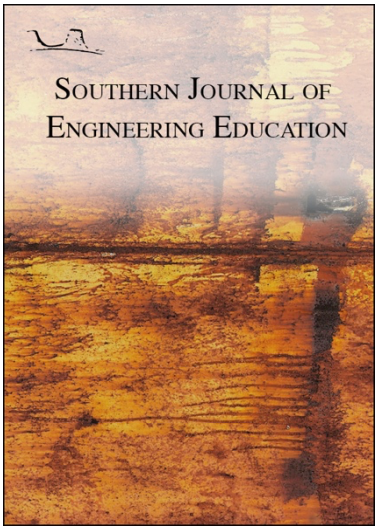

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Following the student-led protests under the umbrellas of #RhodesMustFall and #FeesMustFall, several South African universities made efforts to transform their curricula to make them more relevant to a diverse student population. To this end, the research site for this study, a research-focused historically English-language university, revamped an existing project done by second-year students in their undergraduate chemical engineering programme. This article presents the application of a decolonisation framework to the revised project. Details about the project implementation were collected in the form of the project brief and the six tasks given to students; and semi-structured interviews were conducted with one course lecturer and one tutor. These details were supplemented with inputs from two authors involved in the project design and delivery. The article demonstrates that an engineering design project can be decolonised by increasing its relevance to the local context, valuing student voices in project design, providing opportunities to students for critical reflection, critiquing the existing engineering knowledge, and designing the project to be community-driven. The article specifically highlights the inadequacy of the existing engineering techniques for application in small-scale community-level projects, thus underlining the need for a broadening of engineering knowledge.

Keywords: chemical engineering, community-driven design project, decolonisation, South Africa, undergraduate engineering curriculum

Introduction

The student protests that started in South Africa in 2015 under the umbrellas of #RhodesMustFall and #FeesMustFall developed into one of the most important student protests in post-apartheid South African history, attracting the attention of the country's universities and national and provincial governments (Koopman, 2019). The #RhodesMustFall movement led to a successful campaign to remove the statue of Cecil John Rhodes overlooking the rugby

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field at the University of Cape Town (UCT), and grew into the nationwide #FeesMustFall protests. While the naming of the latter protests made for an easy association with the reduction in the cost of university education in the country, these protests also pointed to multiple forms of exclusion in South African higher education, and hence the urgency to address racial and gender inequities at the universities and decolonise curricula (Postma, 2016; Swartz et al., 2020).

In light of these protests, several universities took initiatives to work on the transformation and decolonisation of their curricula (Koopman, 2019). One such effort at the research site for this study, a research-focused historically English-language university, was to revamp the existing second-year project in the chemical engineering undergraduate programme.

This paper presents an application of a decolonisation framework to the new project. The goal of the paper is to provide engineering educators with an example of designing engineering courses and curricula from a decolonisation standpoint. This article provides details of the project implementation collected through course documents, such as the project brief and the six tasks given to students; and semi-structured interviews with one course lecturer and one tutor. In addition, the original intentionality of the project design is made explicit through details provided by two of the authors of this article. Although student interviews were also carried out as part of this project, those are beyond the scope of this paper.

Literature review

Grosfoguel (2007) notes that with the end of colonialism, the world moved toward a system of global coloniality, which is still present in the minds, psychologies, and worldviews of the then-colonised people. It ‘is maintained alive in books, in the criteria for academic performance, in cultural patterns, in common sense, in the self-image of peoples, in aspirations of self, and so many other aspects of our modern experience’ (Maldonado-Torres, 2007, p. 243) and manifested in the hierarchical relationships between those colonised in the past and their colonisers. In terms of knowledge, coloniality is manifested as an exclusion of indigenous knowledge and portrayal of the Western world as the only source of legitimate knowledge (Quijano, 2007; Smith, 1999).

Decolonisation, or decolonialisation as it is called by some scholars, is therefore not only an end of the territorial, political, and judicial subjugation of the colonised nation by the colonial

powers but is also the termination of the various racial, ethnic, gender, sexual, religious and, for the purposes of this paper, epistemic hierarchies imposed upon the colonised (Maldonado-Torres, 2007). Decolonisation of knowledge can thus be seen from a rejectionist perspective that calls for an epistemic disobedience by mobilising institutions and scholars to challenge the universality of Western conceptualisations of knowledge production and imparting (Chowdhury, 2021).

Decolonisation of curricula

The well-known decolonisation scholar Molebatsi Nkoane (2006) argues that decolonisation of universities and institutions is essential to make them more relevant to the African context. He notes that the African university 'needs to represent the African experience, ideas and finds its resources from within African culture' (p. 54). At the same time, the African university should also emphasise 'mental decolonization from stereotypes and strictures from the past, and mental emancipation for socially and communally engaged scientific projects' (p. 54). Nkoane further notes that mental decolonisation can be achieved by the African people by carrying out an analysis of who they are as people and how their minds and thoughts are controlled by Eurocentric discourses that are not always relevant to their contexts. Thus, Nkoane's notion of decolonisation of the mind resembles the idea of critical consciousness advanced by Freire (1970), who argued that education should empower students to think critically about their lives and situations. In other words, a curriculum should provide students with opportunities to reflect upon their life contexts so that they can recognise injustice in their daily lives, and then enable them to take action against these unjust practices and for social good.

In a summary of the recent debates on decolonisation of the curriculum in the South African national context, the Council on Higher Education (CHE, 2017) outlines four strategies to achieve the decolonisation aims. These include changing the course content, changing the delivery to increase access to higher education, changing the understanding of knowledge that is imparted in universities, and changing who is teaching or researching this knowledge. These four aspects of decolonisation are discussed below in detail.

In the changing of course content, the CHE emphasizes replacing the 'canons' of knowledge that are taught in the universities and are perceived to be Eurocentric with locally-

produced texts and works. Speaking of the presence of the Eurocentric canons of knowledge in the courses and academic degrees at African universities, Nkoane (2006) notes:

> Most modules and/or academic programmes (such as education, science, law, psychology, sociology, political science, law) in different disciplines at African universities are not anchored in or linked to African cultures and realities. The disciplinary problematisations, classifications, examples, illustrations, comparisons, models, social systems and structures, institutions, interpretations and misinterpretations, mistakes and solutions all come from Western realities and socio-cultural constructs. (…) African culture is often only brought up in passing (p. 62).

Similarly, Le Grange (2014) argues that locally-relevant curricula should be designed that move away from the domination of Western epistemologies and challenge the power relation between local and Western knowledge systems. He also advocates for teaching students about the achievements of people in the African continent. He argues that such an understanding can help students free themselves from the dehumanisation that is imposed on them by the Western world. While the change in the canons suggested by the CHE (2017) may mean studying the texts and works produced by local authors in humanities and social sciences, in the natural sciences and engineering, this change may refer to the use of local examples to understand scientific concepts and using scientific knowledge to address problems situated in the local context.

Several educators have previously substituted the existing Eurocentric content with work from other parts of the world. For example, while teaching a thermodynamics course to second-year chemical engineering students at a US university, Riley (2003) gathered resources on inventions such as the still, perpetual motion machines, and underfloor heating in Asia, Africa, and the Arab world and incorporated them in her course. Another example is the approach taken by the Intercultural University of the Indigenous Nations and Peoples, Amawtay Wasi, in Ecuador. In this approach, the pathway to learning at the university follows three stages: the cycle in the formation of ancestral sciences; the cycle of western sciences; and the cycle of interculturality. One of the objectives of this pathway is to help students gain an intercultural education that accepts the diversity of knowledges of the indigenous nations (for a detailed discussion, see DeCarvalho and Flórez-Flórez, 2014). Similarly, instead of discussing Euro-American canonical theories, Morreira (2017) asked her students in a first-year undergraduate social sciences course to read the works of Steve Biko, a South African anti-apartheid activist, to help them learn about the psychological damages inflicted by apartheid on the Black

population. In the field of therapy, Diab et al. (2020) provide empirical examples of modifying the curriculum of psychotherapy and family therapy to address the specific needs of traumatized individuals in the war-torn Gaza Strip.

As regards to changing the delivery of course content, the CHE (2017) argues for debunking the idea of a decontextualised student who is independent of what is taught and learned. Noting that students are social beings who construct an understanding of the reality around them through their experiences, the CHE stresses that knowledge, if presented as a set of value-neutral skills to be learned, can be colonising and alienating for students. It further suggests, '[d]ecolonisation would therefore require deliberate attention to surfacing, and inducting students into, specific forms of meaning-making, with a move away from thinking of curriculum as something received, but rather as a co-constructed set of understandings' (p. 5). By actively engaging the student in the process of knowledge construction, the delivery can increase their access to the knowledge and the relevance of what is learned. These arguments about delivering the course knowledge in a such a way that allows students to be active participants through dialogue and interaction are also advocated by Freire (1970). Drawing on Freire's work, Swartz et al. (2020) also note that a problem-posing education that helps students reflect on the causes and circumstances of their lived experiences, and learn how to transform their lives, is at the heart of decolonising pedagogy. This kind of education necessitates students to engage in praxis, i.e., critical reflection and action based on it to transform the world (Freire, 1970).

Riley (2003) demonstrates how students can act as active participants in knowledge production by asking them to reflect on how thermodynamic principles can be applied to phenomena around them in their everyday lives. Similarly, Padilla (2021) documents engaging students as active participants in learning by asking them to build a greenhouse using indigenous mathematics and, in the process, critically explore the indigenous worldviews in Colombia. Students were also asked to take measurements using their hands as measuring instruments. Parker et al. (2017) demonstrate the practice of engaging students as active participants in knowledge production in a decolonising research methodologies course in the US by asking them to work collaboratively with other students and apply critical reflexivity to construct their course understanding, while the instructors acted as facilitators.

To change the understanding of knowledge, the CHE calls for critiquing the dominant conceptualisations of knowledge in the university. It notes that such current conceptualisations, which are also primarily Eurocentric in nature, are based on a Cartesian duality, which separates knowledge from the knower (Quijano, 2007) and posits that one can only know about reality by being a detached knower. As Thaman (2003) writes, however, decolonising knowledge treats alternate ways of seeing the world as legitimate. Le Grange (2014) argues for moving beyond mere observation and listening as the only legitimate ways of knowing to also recognising knowing 'through the tastes, pain, and hunger of their bodies and through expressions of anger, passion and desire' (p. 1289). Summing up these arguments, Mbembe (2016) notes two aspects of decolonisation of knowledge. The first is to critique the production of knowledge and theories that are based on European or Western traditions. The second is to imagine and develop an alternate model of knowledge production.

Riley (2003) provides an example of critiquing the dominant conceptualisations of engineering knowledge in the university. While teaching an undergraduate thermodynamics course, she asked students to critique the textbook used for the course with a focus on the kind of examples the book used and the kinds that it excluded. Through class discussion with her students, they concluded that the book did not sufficiently include energy systems in developing countries and environmental applications of the theories of thermodynamics. She also highlights the uncertainty in the laws of thermodynamics, thereby critiquing the perceived objective nature of scientific knowledge. In the South African context, Conana et al. (2016) give an example of presenting knowledge in physics in a modified way that treats physics knowledge as less detached and hence more accessible and relevant for students. They show how the teaching of physics can be made less alienating by: presenting physics as a process, rather than a discipline, that is used to model and predict the physical phenomena around us; focusing on how scientific knowledge is constructed; contextualising physics knowledge in the wider social, political, and historical contexts; and presenting physics as a way of knowing along with other systems of knowing. Beyond science and engineering, Morreira (2017) asks her students in her social sciences course to critique the different conceptualisations of Africa in the literature. Moving beyond observation and listening as the modes the learning, Wong (2018), while teaching a postgraduate social work course in Canada, notes incorporating mindfulness in classroom by asking students to work with and learn from their emotions and feelings.

Finally, in addition to whose knowledge is taught, how it is viewed, and how it is taught, the CHE (2017) draws attention to who is teaching or researching the knowledge. It argues that the African experience can only be reliably and authentically communicated by Africans, as assuming that others can communicate the African experience would mean that experience is transferable (Nkoane, 2006). Along similar lines, Le Grange (2014) argues for including ordinary citizens from the indigenous communities as agents of knowledge production.

A prominent example of changing who is teaching the knowledge is the 'Meeting of Knowledges' project implemented at universities in Brazil and Colombia (DeCarvalho & Flórez-Flórez, 2014). As part of this project, masters of traditional knowledges, such as artisans, healers, shamans, traditional architects, and performers were invited to the universities as visiting professors to teach courses in architecture, music, theatre, health, and environment. Prior to beginning their teaching, these masters did an internship in which they listened to the regular classes to learn about the pedagogical practices in the university. Thus, this effort infused the teaching of traditional knowledge with the pedagogical practices at the university. Similarly, Parker et al. (2017), in their course on research methodologies, talk about bringing community experts into the classroom to discuss their work and collaboration with the academics. Saurombe (2018) documents the process of changing knowledge production by encouraging archivers and academics to work together to learn about and create a history of decolonisation of higher education in South Africa.

Decolonisation as an option

While it is important to engage in conversations on decolonisation and take effective steps to achieve this goal, it is important to note here that decolonisation, like the imposition of the colonial and modern hierarchies, cannot be imposed on people. It can be achieved only when people engage in dialogue about what it means to decolonise and envision a world that is based on and constituted through a co-existence of diverse epistemic positions (Maldonado-Torres, 2007). Imposing decolonisation on people like the imperial modernity would be akin to imposing a new form of coloniality on people, renamed decolonisation. Mignolo and Walsh (2018) emphasize that decoloniality is not an end in itself. Rather it is an option along with other options of living and being in the world and should be adopted through praxis, i.e., critical reflection and action on the world to transform it (Freire, 1970).

In line with these arguments, scholars working on decolonisation of curricula do not advocate for a complete removal of the Western and the European canons of knowledge. Rather, they call for an infusion of the Western knowledge systems with the indigenous ones such that 'one knowledge system is not viewed as superior (Western) and other as inferior (indigenous)' (Le Grange, 2014, p. 1292). Similarly, for Mbembe, a decolonised university accepts and embraces '*a horizontal strategy of openness to dialogue among different epistemic traditions'* (Mbembe, 2016, p. 37, italics in original). Thus, what is being advocated is not a rejection of the Western traditions of knowledge production and the already existing theories, but rather a shift in the exclusive focus on the Western traditions to juxtaposing them with the African ones. Ndlovu-Gatsheni (2013) calls this a democratisation of knowledge in that it recognises knowledge from other parts of the world that were once colonised as equally important and relevant.

Resistance to decolonisation of curriculum

While decolonisation provides a viable approach to democratising curriculum and higher education in general, this idea also faces several challenges and resistances in its implementation. The first and foremost challenge to decolonising curricula in science and engineering (which derives extensively from scientific knowledge) is the attitude to the nature of knowledge. Given that the scientific knowledge is largely seen as universal, decolonisation of science and engineering curricula is often disregarded by academics (Blackie, 2019).

The second challenge stems from neoliberalisation of the university. Koopman (2019) argues that the neoliberalisation of the university in South Africa has led to an emphasis on performativity of staff and students in terms of completion of syllabi and attainment of learning outcomes as a measure of success. While this style of management of universities has emphasised training students for the workforce, it has limited for students the 'space for critical thinking and self-directed learning, and to be playful partners in the knowledge construction process' (p. 58).

The third resistance to decolonisation comes in the form of pressure to internationalise higher education. Universities across the world, including those in South Africa, face a pressure to internationalise and compete in global rankings, thereby reproducing curricula and university structures that are Westernised (Knight, 2018; Mbembe, 2016).

The fourth challenge to decolonising engineering curricula is posed by a lack of resources needed to design context-relevant curricula. Senekal and Lenz (2020) note that a significant challenge to decolonising the curriculum in South Africa is the lack of resources in terms of content and time to work on changing the curriculum.

The fifth challenge to decolonising engineering curricula comes from students and academics, including the university leadership. Students often see a localised engineering curricula as something that can impede their career mobility in a globalised engineering workplace (Fomunyam, 2017; Winberg & Winberg, 2017). At times, students also resist an engineering curriculum that pays attention to background and contextual details with a preference for hands-on activities (Winberg & Winberg, 2017). Similarly, several academics 'are content with the status quo and prefer to deal with the devil they know rather than the one they don't' (Senekal & Lenz, 2020, p. 157). This resistance from academics and the institutional leadership continues to perpetuate the colonial hegemony in the curricula (Chowdhury, 2021).

Finally, in South Africa, language poses a severe challenge to decolonise learning with the language of engineering instruction being English or Afrikaans. While there have been movements against Afrikaans as a medium of instruction in universities, the presence of English still creates a barrier to learning for a majority of students in the country who do not speak English as their first language (Dube, 2017). Students in the study conducted by Fomunyam (2017) noted that English as a medium of instruction not only makes learning difficult but also many 'students fail because of this hard language' (p. 6801).

Given the complexities of decolonising an engineering curriculum in light of the nature of the disciplinary knowledge, pressures to internationalise, and resistance from students and academics, Winberg and Winberg (2017) advocate an engineering curriculum that brings together the traditional curriculum with aspects of decolonisation. This curriculum is designed to cater to African needs and has a strong focus on the historical, social, and cultural studies of engineering to help students understand the roots of engineering knowledge. In addition to an internationally recognised qualification and attainment of graduate attributes, it also includes understanding ethical and environmental considerations, valuing diversity, and a focus on the African continent. At the same time, the curriculum proposes the need for taking inputs from

the broader communities that would be affected by engineering work and fostering partnerships with the local industries.

Applying a decolonisation framework to a chemical engineering course project

While there is a growing interest in decolonising the curricula in engineering, there is limited scholarship on its implementation. This paper aims to address this gap by providing an example of decolonising an engineering project taught to second-year students pursuing chemical engineering. It is hoped that this example may provide a model to engineering educators who want to decolonise their teaching and courses.

As noted earlier, following the student-led protests in South Africa, several universities made attempts to decolonise their curricula. To this end, the research site for this study, a research-focused historically English-language university, redesigned the chemical engineering project done by students in the second year of their undergraduate degrees.

The description of the project presented here is constructed on the basis of an interpretivist paradigm using qualitative data. This paradigm was chosen because the project description presented here was co-constructed by the authors in accordance with their interpretation of the decolonisation literature and the details of the project. The sources of data included: 1) course documents such as the project brief and the six tasks that were given to students; and 2) in-depth semi-structured interviews with a course instructor (who was deeply involved in the design of the project), and a course tutor who worked closely with students and the instructor when the project was rolled out. The course documents provided the specific details about the project design and assignments given to students during the project. The interview questions focused on eliciting the key features of the project, the reasons for changing the project, how the project met the goals of decolonisation, and the experiences of the instructor, the tutor, and the students with the new project. Thus, the interviews provided the context and background for the new project. In addition to these two formal modes of data collection, details about the project were also provided by two authors of this paper through the process of discussion and reflection – one of them served as the convener for the project and another was deeply engaged in the design of the project.

The course documents and the interviews were analysed through thematic coding in line with the four strategies outlined by the CHE (2017) as *a priori* categories (i.e., change in the

course content, change in delivery, change in understanding of knowledge, and change in who is teaching/researching knowledge). The four strategies suggested by the CHE were chosen for analysis because of their relevance to the South African higher education context. The analysis was done as recommended by Miles et al. (2014). Initially, the first author read through the data to identify aspects of the project that aligned with the *a priori* categories. During the analysis process, one of the *a priori* categories (i.e., change in delivery) was modified to include three subcategories that emerged from the data. The identified excerpts along with their categories were then shared with the other authors to check for disagreement. Any disagreement in the coding was then resolved through elaborate reflective conversations among the authors. An initial draft of this paper was also shared with the course instructor, who was interviewed earlier, to check for any misalignments in the project details. No disagreement was reported.

The following sections first explicate the context and key aspects of the new project and then discuss how the project design and delivery aligned with the four strategies outlined by the CHE (2017). Excerpts from the course documents and quotes from the interviews are provided as evidence for the arguments made. This work was approved by the concerned Faculty's Ethics in Research Committee at the UCT.

Context of the new project

Since the rollout of a renewed chemical engineering curriculum at the university in 2014, the curriculum requires students to do semester-long design projects in each semester of their second and third years. From 2015 to 2018, the project in the first semester of the second year was industry-based in that it dealt with the design of a large petrochemical plant. The students were required to synthesise a precursor for the production of polymers using refinery products. The project addressed both technical and economic aspects of designing and running the plant, and the project goals were aimed primarily at increasing the overall revenue generation in the process. The only direct connection of this project to the local context was evaluating the potential impacts of running the plant on the nearby town in case of an unforeseen and catastrophic event.

To address the issue of the course project being somewhat removed from the local settings, a new project was introduced in 2019. This project, designed with the aims of decolonisation in mind, involved an analysis of several aspects of the treatment and use of biogas produced

by an anaerobic digester to be installed in an informal urban setting, viz., a food market near a transport hub and urban farming centre, on the outskirts of the city where the university is located. Feed materials to be considered were human excreta, slaughter wastes and garden wastes. The project ran for a full semester (12-13 weeks) with an expectation that students would spend 4-5 weeks on the project task. The remaining weeks were devoted to learning the theoretical concepts required to execute the project.

A community-based organisation (CBO) was seen as the driver of the project, with the teams of student engineers acting only as project consultants. The members of a CBO typically include a community leader who is a respected and influential member of the community, and community activists who are committed to the actions required to bring about change in their communities. Based on the experiences and observations of one of the authors in their interactions with CBOs, the CBO leader(s) and activists foster close ties with the members of their community, community policing forums, public services (e.g., libraries, childcare centres, clinics), religious leaders, ward councillors and other key members of the community. Owing to the logistical and financial constraints of finding and compensating a CBO willing to invest the time and effort to provide an educational framework to students, the project incorporated a CBO through role-playing members. The instructors and the tutors, who acted as CBO members, had considerable knowledge and understanding of the local community in which the project was located through either their lived experiences, or through reading the works of those who had worked in similar communities.

Change in the course content

One of the most significant changes that was introduced in the new project was the incorporation of a locally-relevant problem. As noted earlier, the new project required students to work on the treatment and usage of biogas produced by an anaerobic digester situated on the outskirts of the city. Thus, the project moved the site of engineering learning from an industrial setting that was far removed from the experience of most students to a local setting that was familiar to a greater number of students.

Some students would have grown up or lived in a similar community and thus had lived experience of the project context. However, even for those who had not, the presence of similar communities around the city meant that most students would have travelled past this or similar localities while commuting to and from the university and around the city, and thus would have

had a point of reference to the locality and community in which the project was based. The familiarity of the project context was highlighted by the course instructor during the interview:

> To what extent … is a portion of the class that comes from socially disadvantaged backgrounds, from the types of backgrounds we want to benefit from this, it seemed to me there were people in [the] group that had that relation, emotional or direct through family where they had personal experiences to that.

Furthermore, the raw material inputs to and uses of the outputs of the biogas plant that was to be designed as part of the project were anchored in local experience and culture. An anaerobic digester generates biogas as its main output product from the surrounding waste streams as input material. Starting from the beginning of their work on the project, students were asked to consider the productive use of wastes and biogas in the local context. For example, the first project task asked them to 'give consideration to the **productive** uses of waste and energy (biogas) in an **urban informal** and in an **African** setting' (bold in original). Students were specifically asked to consider (amongst other potential uses) how: (i) a chicken vendor might utilise the biogas for boiling water to pluck chickens; and (ii) a brewer might use the biogas to brew *umQombothi* (local beer). It was anticipated that manumqy students would be familiar with braaied (barbecued) chicken and/or *umQombothi* as they are rooted in local culture.

Finally, the task and project deliverables were intended to move beyond just an academic document and were rather designed to be useful documents intended for use in real-life scenarios. For example, the deliverable of the first task was an infographic whose purpose was to effectively facilitate presentation, communication and discussion with the local community. The final deliverable was a coherent report of the work done to date that could be leveraged in a proposal for the ward councillor or a document with the detailed design and costing that could be used as a framework for soliciting contractors to apply for tenders.

Change in the delivery

The second significant way in which the new project met its decolonisation goals was the change in the way it was delivered to the students. The CHE (2017) emphasises the need for incorporating delivery modes in the curricula that position the students as active participants in the process of learning, thereby increasing their epistemic access to the knowledge in

question. The new project intended to achieve this in three ways: valuing student voices; developing critical awareness in students; and incorporating new sites of project delivery.

Valuing student voices: to increase the epistemic access of students to the knowledge that is expected to be co-constructed in the teaching and learning process, it is important to listen to their voices in the design and delivery of the course materials. To this end, during its design phase, the new chemical engineering project at the research site addressed the students' critiques of the old project. One major critique from the student body was that, after introduction of the social and the environmental impacts of engineering in the first year, the old project abruptly narrowed its focus on the technical and environmental aspects of chemical engineering work. As the course instructor noted during his interview:

> In this course in particular, we had gotten quite a bit of critique from the student body in the years of the challenges on what the university is and how it operates, that the first year had set up an expectation of chemical engineering employed for environmental and social good. The first-year projects all are forward-looking and [involve] an environmental impact, typically: biofuels, hydrogen, water projects… and then second year, they go in and it's like 20th century industrial chemistry… and there's nothing left of this intent.

The new project addressed this critique by situating the project in a local community, and at the same time focusing on the social and the environmental causes of producing energy through waste management.

Developing critical awareness: another significant way in which the new project engaged students in the process of learning was to provide avenues for them to critically engage with the course material through reflection exercises. For example, in the first project task, students were asked to name and critically reflect on their 'inherent biases and assumptions [about] the project context' while reflecting on their 'role as an external agent' in the community and the project. It was hoped that students would be able to engage in productive discussions amongst themselves, leveraging their existing contextual knowledge, to acknowledge and challenge their assumptions.

Similarly, in the sixth and the final task students were asked to 'discuss the social considerations associated with AD (anaerobic digestion) and products in the context of this project, with reference to the process/product options and how they relate to and/or build on the assets of the community identified at the beginning of the project' (Project Task 6).

Additionally, they were asked to reflect on their learning through this community-driven project. Amongst other topics, they were asked to focus on: (i) their roles as future engineers in community spaces; and (ii) the application of chemical engineering knowledge at community scale (vs. industrial scale). The rationale behind asking students to reflect on this aspect was to enable them to imagine their future professional roles in a local context that could serve local needs. Thus, by providing opportunities for critical reflection on the disciplinary knowledge and their roles as future professionals, the project moved away from treating students as decontextualized learners to active participants in knowledge construction.

Changing the site of delivery: another way in which the new project aimed to improve students' access to knowledge was through change in the site of delivery to the site of the project. While traditionally teaching and learning mostly takes places within a classroom setting, the project sought to disrupt this idea by including on-site classes in its initial conceptualisation. It was hoped that through reimagining and expanding the possible sites of teaching and learning to locales more familiar to students, the learning that happened would be more contextualised for students, thereby increasing student access to knowledge. Unfortunately, these off-campus sessions were not included in the final project delivery as the class consisted of more than 100 students and it would have required significant time, cost, and coordination efforts to take these students to the project site.

Change in the understanding of knowledge

The third way in which the new chemical engineering project at the research site addressed the goals of decolonisation was by critiquing existing knowledge and theories and exploring the possibilities of change in understanding of the disciplinary knowledge. As noted above, the new project aimed to connect engineering learning with the lived experiences of the students. To this end, the engineering methods that were used to complete the project also changed in that they focused on applying engineering concepts and theories to the problems situated in the local community context. The process of changing the conceptualisation of knowledge also highlighted the gaps in the current canon of engineering knowledge. As the course lecturer and the course tutor highlighted in their interviews:

> Let's stick with a more practical view here of how do we do a project in a second year that brings the South African context into the project. That's the main bit. And thereby possibly

> challenge the engineering methods our students learn [and] whether [these] can work in such context. (Lecturer)

> The [project] scope remained the same in the case of the key result areas with the experience students do get, but I think the concept changed. [Thus, the new project addressed] that issue of decolonising science and trying to introduce concepts to students which were Africa-based or community based. (Course tutor)

It was realised that while the existing knowledge is adequate for addressing large-scale industrial problems, it is inadequate when applied to a small-scale community project. As the course lecturer highlighted:

> Because the plant was so much smaller than if it had been an industrial plant, all of the wonderful heuristics that are used were out of range…. And so indeed there's a vacuum of engineering methods at community scale work. And that's an important finding actually of this piece of work.

On this issue of knowledge gap, the lecturer also added that one of the important aspects of decolonisation is to develop knowledge and techniques that are suitable to solve the problems of the community in which the engineering work happens. Hence, if engineering work is to happen in a semi-urban community (as was the case with the new project), engineering knowledge that can be adequately applied to solve the problems in that community must be developed.

Change in who is teaching/researching knowledge

The fourth and final way in which the new project addressed the issue of decolonisation was by bringing about a shift in who teaches and researches knowledge. As noted earlier, the primary driver of the project was the CBO situated in the local context. The CBO was positioned as the key knowledge holder that provided enabling inputs to the students throughout the project tasks. The CBO also steered the direction and focus of the students' contribution. The students working on the project only acted as consultants to serve the CBO and the community by providing expertise that was relevant and tailored to the context of the local community, through collaboration with the CBO. The aspect of the students working as consultants was emphasised in the first project task:

> Your first task is to provide a concept note (i.e., a literature review with contextual interpretations) to the CBO on AD [Anaerobic Digestion], including: information about the

> technology; health, safety, environment and economic considerations; and social impacts of the project.… The CBO have asked that you present the information as a poster such that the whole community is able to engage with the information and comment on the possible project.

The subsequent tasks were also designed and worded in a way that emphasised the role of the CBO as the driver of the project and the students as consultants. For example:

> The CBO thanks you for the poster you presented.… However, the poster session also made the community aware of two other issues that could potentially impact on the success of the project. The first is the cost of the storage vessels for the biogas and biomethane…. The second is the safety considerations associated with the handling and storage of biomethane…. Thus, the CBO would like your team to investigate and report on the storage and safety issues. (Project Task 2)

> From the previous task undertaken by the consultant teams, the CBO is now of the opinion that the liquefaction of biomethane (for use as a vehicle fuel) is too capital- and energy- (operating cost) intensive. This leaves two options still under consideration, either:
>
> (i) the use of raw biogas for cooking; or
>
> (ii) upgrading of the biogas to biomethane for electricity generation (in a gas turbine).
>
> Thus, the CBO would like your team to investigate and report on the health, safety & environmental (HSE) and energy implications of these options. (Project Task 4)

In addition to the project tasks being driven by the needs and considerations of the community, the feedback given to the students was also from the perspective of the CBO partner.

The process of positioning the community as the driver of the project was also supported by challenging students to adopt an asset- rather than needs-based mindset, as suggested by Mathews (2013). An asset-based approach positions the community members as drivers of initiatives aimed at their own development. In this paradigm, students identified (with the help of the CBO) the human and material assets of the community and considered how these could be put to use in the process, rather than focusing on the perceived needs (or shortcomings) of the community and doing technical analysis on an imposed solution. For example, for the first task, informed by the reading and their discussions, the student teams were asked to engage in discussion with the CBO to assist them in reaching a common understanding of their respective roles; elements of the project that supported an asset-based approach; and specifically, how to measure and monitor the impact of their work.

By positioning the CBO as the key knowledge holder and the project driver, the project explored the possibility of teaching engineering and doing engineering work through a dialogue with the community that was directly impacted by it. Additionally, it opened up the engineering space for a group of people who, despite being key stakeholders, usually have little say in how engineering projects are designed and executed. Thus, by expanding who gets to have a say in the engineering teaching and work, the project changed who can teach or produce engineering knowledge.

Discussion

The new chemical engineering project introduced at the research site aimed to decolonise the teaching of the discipline by changing the project context, delivery, and the individuals involved in teaching of the project. The project situated the problem that was solved by the students in the local context of an informal urban settlement in line with the recommendations by the CHE and other decolonisation scholars (such as Le Grange, 2014; Winberg & Winberg, 2017). Thus, it brought the context and setting of the project from that of industry (far removed from most students) to one that was more familiar to students, both in terms of lived experience (for some students) and, through regular visual/physical proximity, point of reference of locality and community (for most students). Moreover, by keeping biogas at the core of the project, both the raw material inputs (domestic, small-scale farming and market wastes) and the uses of the products (biogas as well as liquid residues) were anchored in local experience and culture.

In the process of changing the delivery, the project also adopted a Freirean approach to education by developing critical awareness in students through critical reflection exercises and discussions about: (a) their inherent biases and assumptions about the project context; (b) the social considerations associated with the project itself; and (c) their learnings from the project (with an emphasis on their work as future engineers). Thus, the project enabled students to become active participants in knowledge construction rather than being passive recipients of the information (CHE, 2017; Freire, 1970). At the same time, the new project incorporated critiques from the student body, thereby valuing a dialogical approach to education, which is central to a Freirean and decolonising pedagogy (Swartz et al., 2020).

Going beyond situating the project in the local context and engaging students as active participants, the project sought to position the community members as knowledge holders,

contributing to the goal of decolonisation by changing who is doing the teaching (Le Grange, 2014). The project helped students learn from the experiences of the local community by creating a dialogical space between the students and a CBO that was the primary driver of the project. This community-centric approach of the project was also evident in challenging students to adopt an asset-based approach (Mathews, 2013). This aspect of the project design is along the lines of engaging the community in the process of knowledge creation and teaching, which has been advocated by different decolonisation scholars (such as DeCarvalho & Flórez-Flórez, 2014; Parker et al., 2017; Saurombe, 2018).

One interesting and significant outcome of changing the focus of the project from large-scale industrial needs to community needs was that it highlighted the gaps in the current canons of engineering knowledge and particularly the inadequacy of this knowledge (and the information readily available in standard texts) when applied to a small-scale community project. This finding opens up the discussion in relation to what constitutes engineering knowledge and what the domain of engineering work is, thus opening up the possibilities for reconceptualising the disciplinary knowledge to address the goals of decolonisation (CHE, 2017; Mbembe, 2016; Morreira, 2017; Riley, 2003). This should not be seen as an 'either/or' problem, as large-scale production of goods and services is a requirement of both the developed and the developing world, and hence there is a need to create an avenue for different knowledge traditions to co-exist (Mbembe, 2016). To this end, while the project still addressed commercial concerns to help students prepare for industrial jobs, this was balanced with the broader contributions by – and benefits to – the community. Hence, it is acknowledged, and argued here that engineering knowledge should be expanded to include tenets that can also be applied to local small-scale community-driven projects, as previously advocated by other scholars (e.g., Le Grange, 2014; Nkoane, 2006).

While the project met several aspects of decolonisation, there were also difficulties in operationalising the changes needed to facilitate decolonisation. First, the initial project design sought to move the site of delivery from the classroom setting through site visits to provide even greater context for their work, thus moving away from treating students as decontextualised learners to active participants engaged within the project context (CHE, 2017; Freire, 1970). However, due to concerns about student safety and resource constraints, these off-campus sessions were not included in the final project delivery. Similarly, due to logistical and financial constraints, actual community members could not be brought in as project drivers, and instead course instructors and tutors role-played the members of the CBO. These

challenges pose a resistance to decolonising the curricula due to resource constraints (Senekal & Lenz, 2020).

Conclusion

By applying a decolonising framework to a new second-year design project in the chemical engineering undergraduate programme of a South African university, this paper has demonstrated that engineering design projects can be developed to decolonise the thinking of engineering students and teaching staff, by purposefully, and in a consultative way, adjusting the focus, context, and location of these projects. Challenges still exist in the implementation of such projects, principally in the logistics of creating interactions between the students and communities within the constraints of the programme. However, this work provides an example of epistemic disobedience (Chowdhury, 2021) in the field of engineering education, where decolonisation is often disregarded due to the perceived universality of the disciplinary knowledge (Blackie, 2019). The authors hope that the work presented in this paper will provide an initial example and a model for those engineering educators who aim to decolonise their engineering teaching.

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