



#### AUTHORS:

Heila Lotz-Sisitka<sup>1</sup>   
Lesley le Grange<sup>2</sup>   
Gibson Mphepo<sup>3</sup>

#### AFFILIATIONS:

<sup>1</sup>Environmental Learning Research Centre, Rhodes University, Makhanda, South Africa

<sup>2</sup>Department of Curriculum Studies, Stellenbosch University, Stellenbosch, South Africa

<sup>3</sup>Leadership for Environment and Development, University of Malawi, Zomba, Malawi

#### CORRESPONDENCE TO:

Heila Lotz-Sisitka

#### EMAIL:

[h.lotz-sisitka@ru.ac.za](mailto:h.lotz-sisitka@ru.ac.za)

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Chrissie Boughey   
Nkosinathi Madondo

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# Engaged sustainability science and place-based transgressive learning in higher education

This article is located within current debates on engaged science and learning in higher education, with emphasis on types of learning emerging from engaged sustainability science, and associated contributions to debates on decoloniality in higher education. In particular, the article deliberates how a focus on sustainability science practised as place-based transgressive learning can add to debates on decoloniality in higher education. Through analysis of two case studies, we propose that co-engaged place-based research and learning emerges as a form of multi-loop, transgressive learning that offers possibilities for advancing understanding of decolonising learning processes, at least in those parts of the higher education system where the learning and sustainability sciences meet. This is offered as an approach to deepen science engagement in contemporary African contexts.

#### Significance:

- The article offers insight into how science engagement practised as place-based, transgressive learning can contribute to decolonisation of higher education, especially through learning processes.
- It draws on insight from the learning sciences (notably Bateson's work on single, double and triple loop learning, but also theory from decolonial, expansive and transgressive learning) and shows how this can deepen understandings of science engagement practised as place-based transgressive learning.

## Introduction

In the South African Department of Science and Innovation Decadal Plan (2022–2023)<sup>1</sup>, there is a strong commitment to science engagement. However, most references tend to refer to processes of communicating science. There is recognition that science engagement should contribute to scientifically literate societies and that this can enhance inclusivity in science programmes. However, there is no explicit reference to the relationship between science engagement and *learning*, or how such inclusivity processes come about, and there is also no reference to how this should contribute to wider processes of curriculum transformation in higher education. The Decadal Plan<sup>1(p.9)</sup> tends to relate such processes to the need for more inter- and transdisciplinary science, noting that, “A critical defining characteristic of transdisciplinary research is the inclusion of stakeholders in defining needs and hence research objectives and strategies”. However, again, there is no clear link between transdisciplinary research, stakeholders' involvement and *learning*, or what this means for transforming higher education learning processes. It is this gap that this paper addresses.

## Theorising engaged science and learning in higher education with decoloniality, place and transformative, transgressive learning

The efforts towards inclusivity in science practice heralded by concepts of science engagement, and engaged transdisciplinary sciences, can be read more broadly in relation to post-colonial debates about decolonising learning processes, curriculum and higher education research processes. In this paper, we focus mainly on learning processes, with an understanding that these are related to curriculum and research in engaged sustainability science activities. To date, much learning in higher education has been oriented towards individual achievement and progression. This, in our view, raises the need for further inquiry into the *types of learning* that may be more inclusive and thus potentially also transformative (meaning they lead to perspectival shift)<sup>2</sup> or transgressive (meaning they challenge unsustainable norms, forms of oppression and systemic dysfunction)<sup>3,4</sup>.

Internationally, the calls for decolonising higher education research, teaching and learning processes are not new, with Ngũgĩ wa Thiong'o's<sup>5</sup> seminal call for ‘Decolonising the mind’, and Fanon's<sup>6–8</sup> multiple works challenging the paradox of embodied forms of coloniality, including in education, where his call is for a form of ‘lived learning’.<sup>9</sup> Authors such as Ndlovu-Gatsheni<sup>10</sup>, and Mbembe<sup>11</sup> produce interesting multi-layered analyses of the demands for epistemic decolonisation in higher education which, in short, involves *unlearning* coloniality. The question is how should such ‘unlearning’ progress? Various authors offer suggestions; for example, Bozalek and Zembeyas<sup>12</sup> suggest a need to unlearn the coloniality of affects, while others propose unlearning the discipline<sup>13</sup>, unlearning certain expected knowledge sets which calls forth insurgent acts and radical anti-racist imagination<sup>14</sup>, while Mbembe<sup>10</sup> argues that forms of reasoning need to change, as he relates the notion of ‘unlearning’ to the realities of climate change in Africa. Rodríguez Castro<sup>15(p.59)</sup> argues for a “socio-historic, geographic and place-based approach to learning, in which she addresses her positionality through “critical feminist reflexivity, and decolonial and anti-racism work”. In his second thoughts on decoloniality, Mignolo<sup>16</sup> argues that the unlearning of coloniality reaches beyond epistemic transformation and should include serious engagement with land and place, which brings us to a focus on place-based sustainability science engagement and learning in higher education.

Place-based research and learning in higher education has been described by Woodhouse and Knapp<sup>17</sup> as originating from the attributes of a place, being inherently multidisciplinary, being inherently experiential, reflecting an educational philosophy which transcends ‘learning to earn’ and connects place with the self and community. Place-based research and learning, as used in this paper, is premised on a particular understanding of place. Three broad conceptions of place help to differentiate. The first understanding of place dates back to the 1950s and has its origin in the discipline of Geography, whereby place is understood in technical terms as area and locality – as

coordinates on a map.<sup>18</sup> Such a notion of place suggests an abstract notion of dehistoricised spatiality devoid of inhabitants, be they human or more/other-than human.<sup>19</sup> The second is a phenomenological notion of place, based on the idea that in experience nothing is unplaced<sup>20,21</sup>, recognising that we are beings in the world. This is a view of place that is not characterised by universal laws and spatio-temporal space but by distinct neighbourhoods, local events and communities and that recognises that relationships with/to such places elicit feelings, moods, perceptions and attitudes.

Most relevant to this paper, the third broad sense of place concerns a critical, resisting and regenerative notion of place. This notion of place recognises that places have been colonised and, in a neoliberalising world, are characterised by discourses of accountability and economic competitiveness. This view of place also recognises that places can be renewed or regenerated through processes of restoration, maintenance, transformation, care and/or re-membling, which involve the (re) discovery of both self and place.<sup>22</sup> Resisting and regenerating is salient to decolonising places. Mies and Shiva<sup>23</sup> argue that places concern living resistance to colonial constructs of race, gender, nature and value – places mean resisting that which is disembodied, dematerialised and deracialised.

Learning with place in resistant and regenerative ways means transgressively learning and manoeuvring around the “impasses of human agency, the linearity and limitations of capitalist teleology”, in the process upturning the dominating “substructures of our experience as a species”, recognising that, “the very materiality of the world is inescapably entangled with epistemology and justice (or ‘justice-to-come’)”<sup>24(p.828)</sup>. Such a view of place embodies “relations of responsibility”<sup>25(p.265)</sup> or response-ability<sup>12</sup> where researchers and learners are embedded in, and part of the tapestry of becoming. In this article, our framing of sustainability science as place-based research and learning is aligned with the third broad notion of place, because it concerns researchers and students learning sustainability together with/in local communities and through culturally attuned, and place-centred democratic processes. Here, sustainability concerns of local communities in place form the primary focus of engagement, and learning is not left to individuals for independent progression, but is rather oriented towards socially situated, place-based reflexivity and change that respect and take account of indigenous people’s epistemologies, ways of being and experiences.<sup>26</sup>

With the above discussion on science engagement and (un)learning in mind, we draw on Bateson<sup>27</sup> whose work makes it possible to differentiate between types of learning using a recursive conceptualisation of first, second and triple loop learning<sup>28</sup>. We draw on this because it is also widely used in the sustainability sciences to frame empirical studies on learning.<sup>29,30</sup>

**First loop learning** (Level I in Bateson) sees learning primarily as science-based information transfer leading to acquisitional outcomes for the individuals concerned, i.e. learning *about* and *for* sustainability concerns.

**Second loop learning** (Level II in Bateson) sees learning outcomes as socially critical engagements with causes of environmental problems, with learning being constituted both *for* and *as part of* the sustainable development process. **Triple loop learning** (Level III in Bateson) sees issues as complex, and learning outcomes as uncertain, constituted by ongoing reflexive processes of social or collective forms of learning ‘what is not yet there’<sup>31–33</sup> in and from place, relations and context. Bateson<sup>27(p.302)</sup> talks about this learning as perceiving and acting “in terms of the contexts of contexts”, denoting the need for contextual critique, unlearning, reflexivity and the kind of regenerative place-making mentioned above. This type of learning embraces indeterminacy, ontological and epistemological plurality and multi-voicedness, thus offering potential for the type of resistant, regenerative and transgressive learning referred to above.

## Methodology

To provide an empirical base for elaboration of our argument, we draw on two case study examples of sustainability science engagement practised as place-based research and learning. A case study is typically “an empirical inquiry that investigates a contemporary phenomena (‘the case’) in depth and within its real world context”<sup>34(p.16)</sup>. In each case, researchers focused on how the place-based expansive learning was constituted and emerged over time. In both cases, researchers were

positioned as co-engaged researchers using co-engaged methods typically used in expansive learning research, which involve developing understanding of the contextual dynamics, challenges and questions with actors in the context, and probing these together to identify and work out alternatives to contradictions, problems and challenges experienced by people in the contexts concerned, typically also leading to transformative agency and changes in the settings.<sup>35,36</sup> Thus, both cases are case studies of expansive, transgressive learning with communities in complex socio-ecological relational configurations (cf. Table 1). In each case, postgraduate scholars working in the sustainability sciences collaborated with lecturers and other students (e.g. diploma or degree students) and a range of community actors (e.g. government officials, non-governmental organisations, farmers associations), to undertake co-engaged research and learning with communities around place-based matters of concern that affect the communities they engage with (e.g. water for food, food insecurity). Expansive, regenerative learning actions emerged over time, with the collaborating participants together uncovering and unlearning taken for granted norms, and reflexively learning ‘what is not yet there’ in the contexts.<sup>32</sup> Each time the matters of concern and the associated groups were co-defined in place-based contexts.

## Case studies of sustainability science and place-based transgressive learning

The first case (led and documented by Lotz-Sisitka et al.<sup>35</sup>), developed over an 8-year period of extensive ongoing co-engagement, emerged in the rural Eastern Cape, South Africa, where postgraduate scholars from two universities and diploma-level students in an Agricultural Training Institute (ATI) have been working with rural farmers on sustainability challenges related to land and water for food production in a post-apartheid land reform setting where indigenous farmers were given back their land. Farmers were being given some support from the local government to develop sustainable agriculture as a means of economic production and livelihood, but they had little or no access to water.<sup>35</sup> The second case (led and documented by Mphepo<sup>36</sup>) emerged in rural Malawi, and developed over a 4-year period, where postgraduate scholars and degree-level students in the local university were working with rural women farmers to increase agricultural production in the face of regular ‘drying’ of the local lake system.<sup>36</sup> In both cases, small holder farmers were affected by drought conditions, which were reported and recorded as being more severe than earlier times.

While each of these cases documenting processes of sustainability science place-based research and learning are extensive<sup>35,36</sup>, in Table 1, we highlight some of the most salient features of the processes followed, outlining the place-based co-engaged learning sequence and ontological and epistemological dynamics involved, including the outcomes of the place-based research and learning processes over time. We also point to the ‘unlearning’ that was involved in each case. We purposefully draw on cases from two different southern African countries, to broaden our insight into decolonial learning processes informed by experiences on the African continent, not only South Africa.

In Table 1, we summarise key contours of the learning processes in the two cases before discussing them in more depth.

## Discussion of the cases

As can be seen from the above cases, there are interesting insights into the sustainability science engagement research and learning processes, which include:

- the importance of diverse perspectives and different forms of knowledge converging through co-engaged interactions over time, and identification of what needed to be ‘unlearned’,
- the grounded nature of the matters of concern that are place-based and embedded in human–environment relations, local cultures and knowledges,
- relationality is core, involving nature-culture relations as well as critically constituted relations of empathy, care and solidarity, all of which provide motive for learning and which grounded both resistance and regenerativity in place.



**Table 1:** Cases of science engagement as place-based research and learning processes

Features of the unfolding place-based research and learning process	Case 1: Access to water for food production in rural smallholder farming communities (Eastern Cape, South Africa) <sup>35</sup>	Case 2: Women's empowerment in food production in climate change adaptation programmes (Lake Chilwa, Malawi) <sup>36</sup>
<b>Context of the research and learning processes</b>	Smallholder farmers in the rural Eastern Cape were given back land via land reform in post-apartheid period but had no access to water. There was local economic development support for their practice, but no support for water infrastructure maintenance and supply.	In the Lake Chilwa area in Malawi, communities are dependent on fishery. Levels of poverty are high, and the area is experiencing periodic droughts that lead to 'drying up' of the lake. This has a significant impact on local food security and puts additional pressure on women farmers.
<b>Matter of concern as articulated by communities in place</b>	Farmers were seeking support for addressing their 'water for food' problem. They wanted to know more about rainwater harvesting and conservation (RWH&C) practice relevant to their scale of farming.	Women farmers were experiencing food insecurity stress as a result of the lake drying up. They have valuable indigenous and local knowledge of food production (including the use of Open Pollination Variety (OPV) seeds), but this was being undermined by extension officers who were promoting mono-culture and hybrid seeds.
<b>Sustainability-oriented challenges identified</b>	Drought was reported to be more frequent in the area, affecting already difficult conditions for developing farming enterprises.	Drought affects normal food production rhythms, where conditions of poverty are already severe. Women household food producers are most under stress.
<b>Learning-oriented challenges identified – including what had to be 'unlearned'</b>	Excellent information available on RWH&C practices produced by the scientific community, even available in the local Agricultural Training Institute, but not being used due to historical influence of mono-culture agriculture dominance in the curriculum; the latter needed to be 'unlearned' to make space for more plural accounts of agriculture.	Some knowledge available on climate change adaptation practices. The validity of women's indigenous knowledge, however, was marginalised. Dominance of mono-culture and hybridised seeds being promoted by extension services and scientific organisations, including local scientists and market actors, with both patriarchal dominance over what counts as valid knowledge and agriculture mono-cultures needing to be unlearned.
<b>Summary of the co-engaged research and learning process followed</b>	There was a common interest in advancing knowledge of RWH&C to address the smallholder farmers' problem, among farmers, and local economic development officers, Agricultural Training Institute lecturers and farmers' association. A learning network was formed, supported by a 'navigation tool' that gave access to more detailed information on 26 RWH&C practices (produced by water scientists for the Water Research Commission). The learning process started with mobilising local indigenous knowledge of farmers, which created space for further choices of RWH&C practices and development of collective demonstration sites. The collective demonstration site process expanded over time across the community. Farmers started assisting each other and an indigenous collective farming practice 'illima' was re-instituted in the community, and offered practice-based learning opportunities for Agricultural Training Institute students. Community radio tools and digital tools such as WhatsApp were also used for wider social learning and ongoing knowledge exchange and co-learning.	There was a common interest in finding ways of responding to the implications of the drying lake and its impact on local food security, especially among women farmers and non-governmental organisation partners, and the university research team. A process of working with the women farmers to surface their knowledge and learning was initiated, and a scenario-building approach was used to surface women's desired options for resolving the matters of concern. This combined science and arts-based methods and offered a cultural translation tool to approach the gendered environment. This led to the establishment of comparative demonstration plots where women's indigenous agricultural knowledge was applied and compared to the production resulting from the knowledges being shared by extension services. The university and students assisted with scientific analysis of the resulting production processes and outputs. This helped to both surface and validate the women's knowledge which showed higher levels of production output from a food security point of view. This also addressed some of the gender-based challenges identified.
<b>Features of the ontological and epistemological experiences reported</b>	Motivation to seek out new knowledge was grounded in matters of concern of interest to the communities in place. Indigenous knowledges provided means of evaluating and expanding existing knowledge and experience. Co-defined approaches providing access to new knowledge and co-engaged critically situated experiences (e.g. demonstration plots development) helped with identification of knowledges necessary for advancing practice in co-defined ways. Empathy for older women farmers was catalytic in establishing the learning network and solidarity relations, which were crucial in catalysing regenerative collaborations in place.	Motivation to seek out different approaches to food security as a climate change adaptation strategy was grounded in the matters of concern of the women farmers in place. Indigenous knowledges were surfaced, as well as local gender and modernisation politics that were subjugating women's knowledges. Through arts-based methods, new communication tools were developed, which produced spaces for a wider scope of knowledges to emerge and be tested out in practice. The materiality of the indigenous farming practices was crucial to the resistance and regenerativity in the context. In the process, new relations of solidarity were created.
<b>Observations on place-based transgressive learning</b>	Learning was iteratively grounded in encounters with situated, historical, existing and new knowledges. These were combined iteratively over time with critical analysis of the status quo (why water systems were not in place) and trying out new theory-practice combinations that seemed feasible and meaningful to the socio-material situation. The process was multi-voiced and recursively expansive around the matters of concern over time.	Learning was iteratively grounded in encounters with situated, historical, gendered, existing and new knowledges. These were combined and evaluated through a critical analysis of politics of subjugation, which allowed for surfacing marginalised knowledges of women, and trying out alternative possibilities, and making their validity more visible through experimentation and dialogue. The process was multi-voiced and recursively expansive around the matters of concern over time.

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Table 1 continued...

Features of the unfolding place-based research and learning process	Case 1: Access to water for food production in rural smallholder farming communities (Eastern Cape, South Africa) <sup>35</sup>	Case 2: Women's empowerment in food production in climate change adaptation programmes (Lake Chilwa, Malawi) <sup>36</sup>
Documented outcomes of the place-based research and learning processes for farmers, students and other actors	<p><b>For farmers:</b> they were more able to test out and use a wider range of RWH&amp;C practices and were able to gather support and new knowledge resources for their practice; improving food production at local levels and validation of their indigenous knowledge and practices, while also expanding these. Stronger relations of solidarity were also established which they continue to draw on.</p> <p><b>For students:</b> they were more able to iteratively relate theory and practice, and their modalities of learning were expanded and more substantively grounded in the materiality and social experiences and knowledges of communities, equipping them better for responding to risk and matters of concern.</p> <p><b>Other actors:</b> the solidarity network strengthened relations of empathy and community building and has equipped diverse actors to be more responsive to farmer's needs, a tendency that has shaped curriculum review in the Agricultural Training Institute, and ongoing supportive engagement with farmers over a period of approximately 10 years now.</p>	<p><b>For women farmers:</b> increased levels of food production; validation of their indigenous knowledges and embodied knowledge and practices; changed gender relations; stronger solidarity networks that validated their status and capabilities as primary food producers building on their socio-material relations with the land and food production processes.</p> <p><b>For students:</b> more able to iteratively relate theory and practice; develop insights into the validities of a diversity of forms of knowledge; to ontologically ground their learning; equipping them better for responding to risk and matters of concern.</p> <p><b>Other actors:</b> a wider repertoire for responding to recurring drought conditions, and abilities to use multi-methods that include aesthetic processes, and complex conversations such as those arising in the gendered environment. Relations of empathy and community building and solidarity networks strengthened, with ongoing networks of supportive co-learning in place.</p>

In both cases, we see resistance and regeneration being co-constructed in place-based contexts in multi-actor formations as no one form of knowledge or experience was seen as adequate in responding to matters of concern. In both cases, a plurality of knowledges and forms of engagement were sought out in collectives, through the situated, place-based engagements with matters of concern that were shared. In both cases, coloniality shaped unsustainable practices were identified which had to be 'unlearned' (e.g. dominance of mono-culture agriculture in Case 1, exclusion of rural women's knowledges in modern extension services in Case 2). Solutions were not pre-determined or fixed, and alternatives to what were perceived to be unsustainable norms or oppressive practices were co-constructed through different co-engaged learning and relational change processes (e.g. in Case 1, they used a 'navigation tool', and in Case 2, arts-based scenario methods, and in both Cases 1 and 2, they used demonstrations). In both cases, indigenous knowledge and other forms of knowledge were mobilised concurrently to resolve contradictions and problems being experienced. In both cases, solidarity relations and network building were key to the sustainability science engagement practised as place-based research and learning process.

Mainstream science learning processes, and even recommendations for 'communication approaches' to science engagement in higher education tend mostly to advance forms of first loop learning. With the need for co-engaged transdisciplinary approaches to sustainability science being articulated as a strategy for inclusivity in the sciences<sup>1</sup>, and drawing on the learning sciences mentioned above<sup>27,28</sup>, one could easily argue that second and third loop learning might better guide decolonial place-based learning and that these ways of describing the unlearning and regenerative learning better reflect the learning in the two cases. This could easily lead to instrumentalising such learning processes in higher education.

However, a more nuanced reading of the literature on first, second and third loop learning warns of instrumentalising reflexive and transformative learning (especially triple loop learning) as a "a form of deeper strategic thinking" that seeks "utopian solutions through ever higher orders of learning"<sup>28(p.303)</sup>. Tosey et al.'s<sup>28</sup> point is that triple loop learning is often erroneously interpreted as an "ever higher" order of learning and that learning at Level III in Bateson's original work<sup>27</sup> (from which most triple loop learning applications are derived, including in the sustainability sciences) is not achievable by 'instrumental means'.<sup>28</sup> Instead, such learning is generative and unpredictable and by definition not controlled,

indicating that educators or researchers are not able to engineer the future by turning these processes into pedagogical methods and that such processes should necessarily remain open-ended. Furthermore, Tosey et al.<sup>28</sup> point to the complexity of Bateson's Learning III, noting further that it differs from most adopted conceptualisations of triple-loop learning in that it reveals a dark, difficult side to transformation, is non-instrumental, exists beyond language and is recursive"<sup>28(p.303)</sup>. Reynolds<sup>37</sup> argues that interpretations of triple loop learning may benefit from "being grounded more in understanding, engaging with, and transforming social realities", as in our two cases (cf. Table 1). Essentially, this more careful reading of the learning science literature in the context of sustainability science engagement and learning raises the question of open process, rather than controlled pedagogy.

Interesting too, Bateson does not reduce Learning III to rational deliberation or discussion, but he includes the role of the unconscious and aesthetic, "saying that learning entails a double involvement of primary process and conscious thought"<sup>38</sup>, accommodating not only 'hard facts' but references to emotions, aesthetics, spirituality, the sacred and "transconceptual experience"<sup>38(p.61)</sup>, for example, the unlearning of colonial 'affects' as argued by Bozalek and Zembleya's<sup>12</sup>, or Fanon's 'living learning'<sup>9</sup>, as was the case for women in Case 2, and also in Case 1, if less explicitly. Tosey and Mathison<sup>39</sup> propose a development of Bateson's original framework with emphasis on "multiple modes of learning" (i.e. embodied, analytic and aesthetic) identified in Bateson's writing, which we see arising the two cases above where the embodied significance of demonstration sites (the kinds of 'living learning' referred to by Fanon's work<sup>9</sup>) in Cases 1 and 2, and the use of arts-based methods for co-producing alternative views and possibilities in Case 2, led to planting practices with rural women that helped them to challenge patriarchal and oppressive relations, and affirm their indigenous knowledge, leading to significant food system benefits. This leads us to consider what has not yet been considered adequately in the learning sciences, namely, aspects of aesthetics, cosmology and arts in the opening up of possibilities for expanded third loop learning interpretations as articulated by Tosey and Mathison<sup>39</sup> and thus also decoloniality of learning processes.<sup>40</sup> We also note that our cases reflect a recursive relationality between first, second and third loop learning premises, as outlined in Figure 1 (i.e. the processes were not separate but iteratively related), a relation that Bateson<sup>27</sup> also alerts us to in his original work. What is interesting is that Bateson noted that Level III learning is extremely difficult for individuals in constrained psychological



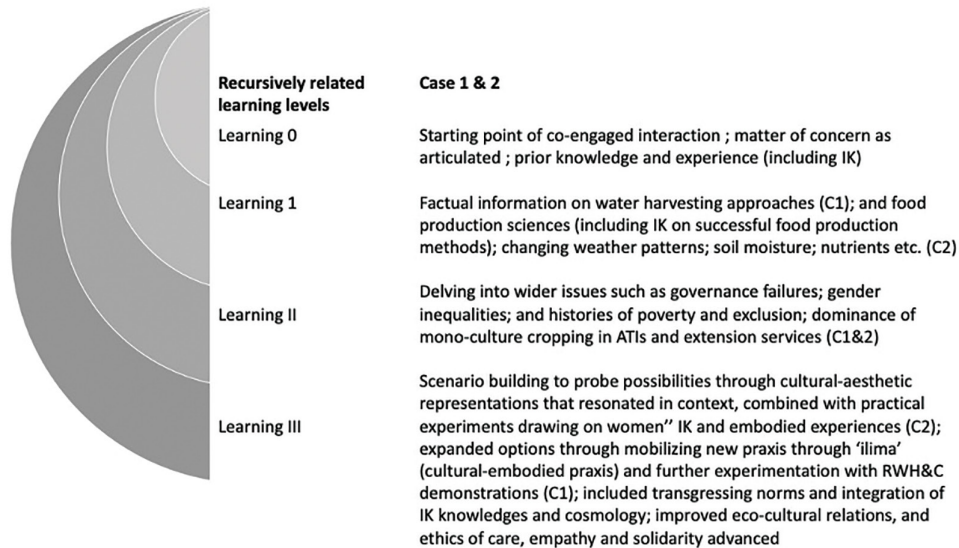


Figure 1: Case interpretations of Bateson's<sup>27</sup> recursive levels of learning.

learning experimental conditions, but our cases, along with other related research, shows that this seems to be less so in place-based transgressive learning collectives.<sup>32,33</sup>

The cases also show the need for explicitly including a focus on transgression in discussions on triple loop learning, especially transgression of unsustainable norms and practices (e.g. transgression of mono-culture agriculture and high-intensity irrigation praxis, dominant narratives of hybrid seeds of extension officers, dominant patriarchal cultures marginalising women's knowledge)<sup>3,4,35,36</sup>, as these seem to be where co-learners are collectively able to practice those reflexive processes of perceiving and acting "in terms of the contexts of contexts", which, as noted above, Bateson<sup>27(p.302)</sup> refers to as being a key feature of Learning III, difficult as this is. Our cases show that this can help to overcome the nature-culture bifurcation, fact-value and expert-novice dichotomies that characterise mainstream higher education learning processes, where the emphasis remains mainly on acquisition of disciplinary knowledge. As indicated above, decolonial theory and associated studies articulating what needs to be 'unlearned' emphasises these limitations and argues for a need to broaden ways of knowing and the scope of knowledges and forms of learning encountered in higher education.<sup>40-42</sup>

Importantly to the discussion of our cases, and the emerging argument, is that the dualist logic of Western modernity has seen an artificial separation between indigenous and Western science knowledges.<sup>40,42</sup> As a consequence of European colonialism/imperialism, modern Western science has been given the superior status of 'knowledge', whereas the knowledges of colonised people are regarded as mere 'culture'.<sup>43</sup> The superior status given to Western modern science and its constructed separation from indigenous knowledge has been challenged by decolonial scholars, postcolonialists, feminist philosophers of science, multiculturalists, sociologists of knowledge, and so on.<sup>42</sup> An imperialist view of knowledge privileges representation rather than performance and declares knowledges as different, superior/inferior. However, when the performative side of knowledge is accentuated as in our two cases and via the recursive single-triple loop process (Table 1 and Figure 1), then science and engaged science is understood as a situated activity which connects people, sites, place and forms of knowledge relationally. In other words, science/knowledge is locally co-produced through processes of negotiation based on the social organisation of trust and the co-construction of meaning using diverse approaches to knowledge (e.g. drawing on indigenous knowledge while also conducting comparative science experiments on productivity related to local indigenous knowledge as in Case 2). It is not reliant on empirical verification/falsification as the only means of valorisation. Viewed in this way, seemingly disparate knowledge traditions can work together to produce new knowledge in new knowledge spaces, and/or regeneratively

recover the existing validity of marginalised knowledge<sup>42,36</sup>, enhancing sustainability science engagement beyond 'communications'.

While the curriculum is not the focus of this paper, if applied to the curriculum and its strong relation to learning, such learning positions the curriculum as an active force<sup>44</sup>, meaning that the curriculum is not predetermined but immanent to the present situation of places and an outcome of the intra-actions that occur among humans and in relation with the more than human via the learning process. In other words, the curriculum is always curriculum-to-come. This view of curriculum is aligned with discussions on transgressive, regenerative and triple loop learning deliberated above, as well as decolonial<sup>32</sup> and some forms of posthuman curriculum theorising<sup>45,46</sup>. Curriculum can be conceptualised as 'transgressive moment'<sup>47</sup> if science engagement approaches such as those in Table 1 are developed as open process service learning or other engaged learning programmes in higher education (avoiding instrumentalisation as noted above). In our cases (Table 1), we can see that sustainability science engagement can be a transgressive movement<sup>3,4</sup>, constituted as an open process of unlearning, co-learning and becoming in place for researchers, community members and other actors alike, with the potential to inform curriculum transformation and learning theory development in higher education.

## Conclusion

In this paper, we have sought to offer a perspective on how place-based learning and research can be conceptualised and enacted as sustainability science engagement in higher education settings. As can be seen from the two cases in Table 1, this requires that academics and students collaboratively co-engage with communities around their matters of concern in place, and in the process involve other actors (including the more-than-human) and a plurality of cultural tools (e.g. diversity of knowledges as well as ethics of care, solidarity and empathy and sensibilities to a plurality of eco-cultural relations). These all work together to support communities and academics and students to unlearn, and learn how to respond to their particular matters of concern through emergent processes that are reflexive in and of context, and which remain open-ended, creating new or regenerative possibilities for being and becoming in practice, in the process breaking away from modernist and colonial dualisms. Confronting structural and/or historical challenges and contradictions and challenges with others can lead to identifying what needs to be unlearned and regeneratively replaced. Allowing for open processes of learning creates space for possibilities to be elaborated via co-engaged attempts to resolve these contradictions and challenges in embodied multi-actor formations where students in universities offer relations of solidarity and care, as well as research-based support, co-learning from the process.

Our argument is that sustainability science engagement, conceptualised and practised as place-based forms of transgressive learning, can extend conceptualisation of science engagement beyond communication to give deeper meaning to inclusivity. Our cases show this can extend decolonial practices in higher education and can also help to answer the 'how' question in how transdisciplinary science practice can unfold, at least in those parts of the higher education system where the learning and sustainability sciences meet.

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## Data availability

Data used to construct the two case studies are available from the authors on request.

## Declarations

There are no competing interest declarations associated with this research. We did not use AI in the preparation of this manuscript.

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## Authors' contributions

H.L.-S.: Conceptualisation (partial); literature review (partial); methodology development for Cases 1 and 2; data collection oversight for Cases 1 and 2; data analysis for Case 2 (partial); data curation; writing – the initial draft (partial); writing – second draft (full); student supervision for researchers in Cases 1 and 2; project leadership of Cases 1 and 2; and funding acquisition for Cases 1 and 2; funding acquisition for writing collaboration. L.L.G.: Conceptualisation (partial), literature review (partial); writing – initial draft (partial); review (second draft). G.M.: Conceptualisation (partial), data collection for Case 2; data analysis for Case 2; validation; data curation (Case 2); writing – the initial draft (partial, mainly Case 2); review (second draft); field-based leadership (Case 2). All authors read and approved the final manuscript.

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