Peer review history for:

Rosenberg E, Cockburn J, Reed M, James W, Gengelbach J, Walk H. Evaluating innovation in transdisciplinary sustainability education: TRANSECTS' international learning labs. S Afr J Sci. 2024;120(9/10), Art. #17957. https://doi.org/10.17159/sajs.2024/17957

HOW TO CITE:
Evaluating innovation in transdisciplinary sustainability education: TRANSECTS' international learning labs [peer review history]. S Afr J Sci. 2024;120(9/10), Art. #17957. https://doi.org/10.17159/sajs.2024/17957/peerreview

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Reviewer A: Round 1
Date completed: 27 March 2024
Recommendation: Accept / **Revisions required** / Resubmit for review / Decline
Conflicts of interest: None

Does the manuscript fall within the scope of SAJS?
Yes/No
Is the manuscript written in a style suitable for a non-specialist and is it of wider interest than to specialists alone?
Yes/No
Does the manuscript contain sufficient novel and significant information to justify publication?
Yes/No
Do the Title and Abstract clearly and accurately reflect the content of the manuscript?
Yes/No
Is the research problem significant and concisely stated?
Yes/**No**
Are the methods described comprehensively?
Yes/**No**
Is the statistical treatment appropriate?
Yes/No/**Not applicable**/Not qualified to judge
Are the interpretations and conclusions justified by the research results?
Yes/**Partly**/No
Please rate the manuscript on overall contribution to the field
Excellent/**Good**/Average/Below average/Poor
Please rate the manuscript on language, grammar and tone
Excellent/**Good**/Average/Below average/Poor
Is the manuscript succinct and free of repetition and redundancies?
Yes/No
Are the results and discussion confined to relevance to the objective(s)?
Yes/No
The number of tables in the manuscript is
Too few/Adequate/Too many/**Not applicable**
The number of figures in the manuscript is
Too few/Adequate/Too many/**Not applicable**
Is the supplementary material relevant and separated appropriately from the main document?
Yes/No/**Not applicable**

Please rate the manuscript on overall quality

Excellent/**Good**/Average/Below average/Poor

Is appropriate and adequate reference made to other work in the field?

Yes/No

Is it stated that ethical approval was granted by an institutional ethics committee for studies involving human subjects and non-human vertebrates?

Yes/**No**/Not applicable

If accepted, would you recommend that the article receives priority publication?

Yes/No

Are you willing to review a revision of this manuscript?

Yes/No

Select a recommendation:

Accept / **Revisions required** / Resubmit for review / Decline

With regard to our policy on 'Publishing peer review reports', do you give us permission to publish your anonymised peer review report alongside the authors' response, as a supplementary file to the published article? Publication is voluntary and only with permission from both yourself and the author.

Yes/No

Comments to the Author:

This report provides comments that authors may use to strengthen their proposed publication and make it readable to their audience. In my assessment, I can testify that the main questions the authors set themselves has been successfully answered.

The proposed publication is useful in that it discusses Transdisciplinary Education Collaboration for Transformations in Sustainability at the intersection of universities and UNESCO Biosphere Reserves. The proposed publication explores the effectiveness of an innovative curricula to engage participants in potentially transformative experiences that enable students to learn different ways of analysing complex sustainability challenges including how to work collaboratively towards solutions. I am sure many readers will find it useful and hopefully teachers and other sustainability practitioners will use the findings to strengthen and mainstream their own work. However, to make the proposed publication more robust and to increase its usefulness, I think the authors need to address the following.

1. The research problem is not quite significant and it needs to be concisely stated.

2. It is important for the authors to address the fundamentals of sustainability education (empowering people and communities with capabilities to confront and deal with the challenges of the 21st century) when discussing the findings.

3. Innovations in education are usually characterised by disrupting the status quo. It is not clear from this evaluation report what the project is attempting to disrupt as the innovators tried their transformative concepts that may have (or not) resulted in transformative practices.

4. I also think that important contributions of educational scaling research is not mentioned or addressed, contributions that I think could strengthen the evaluation findings.

There will be need for clarity at several points. I have made some comments and concrete suggestions in tracked changes on ways the chapter can be improved.

Overall, this proposed publication puts together a useful case of transdisciplinary learning and research that will be relevant to a wide range of sustainability education practitioners internationally.

Content

Novelty

This proposed publication has quality potential and is unique in the field of environment and sustainability

education. It can turn out to be an important evaluation study in that it highlights important curriculum development issues in the relationship between universities and other stakeholder organisation with an interest in effective sustainability pedagogies that enable (or hinder) the development of sustainability competences.

Abstract and titles

Abstract

Before stating the findings in the abstract, the authors need to describe the methodology and tools used to generate and analyse data.

Title

I propose this title: Evaluating innovation in transdisciplinary sustainability education: The case of TRANSECTS' International Learning Labs

Literature Review

I am satisfied with the literature review with the concepts discussed. I however feel the authors could have included a discussion on transformative learning or what they call "transformative sustainability education".

Methodology and methods

The methods section is a weak point in my opinion. The authors should describe the methods of data collecting and data analysis. There should be absolute clarity on how they arrived at their findings, e.g. how did the authors arrive at the "three domains of change" line 195?

Presentation

See comments in the proposed publication

Scientific conduct

See comments in the propose publication

Ethics

I cannot confirm that the authors have provided an explicit statement of approval by an institutional ethics committee.

[See Appendix 1 for Reviewer A's comments made directly on the manuscript]

Author response to Reviewer A: Round 1

The research problem is not quite significant and it needs to be concisely stated.

AUTHOR: We have provided the evaluation questions, pointing out that they are also our research questions. We have edited the text to make this clearer.

It is important for the authors to address the fundamentals of sustainability education (empowering people and communities with capabilities to confront and deal with the challenges of the 21st century) when discussing the findings.

AUTHOR: We have added several new references and expanded on the topic in the text. However space does not permit us to elaborate beyond what we've now added to the Literature Review, and what is in the Discussion.

Innovations in education are usually characterised by disrupting the status quo. It is not clear from this evaluation report what the project is attempting to disrupt as the innovators tried their transformative concepts that may have (or not) resulted in transformative practices.

AUTHOR: We thought that this was addressed under the heading "The need for pedagogical innovation in higher education". Nonetheless, we added more literature on transformative sustainability education. Please also refer to the Discussion comparing Field schools and Learning Labs, which makes it clear that the latter have a transformative intent that the former do not have.

You mention it later, but you could make the point already here: You implicitly state that students'

backgrounds from three continents provide rich(er) learning opportunities e.g. on how to work and function together.

Suggestion: Make this statement explicit.

AUTHOR: Thank you for the suggestion; we made the point more explicit, now also earlier on in the manuscript (highlighted in yellow).

Enhance clarity: congruent to what? (to the concept of the innovative and transformative L-Lab)… -> a conceptual congruent, innovative evaluation framework.

AUTHOR: Clarified with "aligned" - referring to the first part of the sentence, i.e. aligned with the transformative intent.

Reference is problematic (due to its style, see there).

AUTHOR: This is a reference to pre-test post-test evaluation methodology and its critique.

Possibility that this reference should point to 28: Weiss, CH. Nothing as Practical as Good Theory: Exploring Theory-Based Evaluation for Comprehensive Community Initiatives for Children and Families. In J. Connell, A.

Kubisch, L. Schorr, C. Weiss. (Eds). New approaches to evaluating community

AUTHOR: Yes, it refers to Weiss. References now revised. Thank you.

It could be interesting for the reader to compare the tabular log-frame with the graphic version, e.g. the tabular log-frame could be given in the appendix. The changed tabular log-file for Fig 2 would be interesting, too!

(Just as an example to point out why a visual representation does provide benefits).

AUTHOR: Yes, we have now added the tabular log-frame (new Figure 1) and agree this is an improvement.

Although I can follow this thought, I would like to point out that making „real opportunities to take actions" a mandatory ingredient of learning-experiences in transformative learning weakens those approaches where theoretical approaches to solutions, e.g. prototyping on a conceptual level, are promoted.

Suggestion: weaken (or open) this statement, e.g. „profit from" instead of need (if you agree with that). Or e.g. add a reference where the necessity is pointed out.

AUTHOR: We have weakened the statement to "If higher education is to catalyse and enable new ways of thinking, valuing, and doing, it may require …"

Here or later: In this text there is no information about the length of a TILL, e.g. it is necessary to consult the referenced program.

It might be helpful to the reader to give a little bit more details, e.g. length of TILL (for example in 2023), and number of students involved.

In addition: See remark further down for information about number of mentors involved and ratio students/mentor.

AUTHOR: Added.

It is clear that you make a difference between Learning Lab and Field school, and that Lab refers to Learning Lab.
However, personally I would prefer if you could add a visible difference between a Lab and your format „Learning Lab" and stick to it throughout the text, e.g. maybe use L-Lab or the full two words Learning Lab: In the L-Lab the problem is probed… makes this special format clearer to the reader.

AUTHOR: Added "Learning" to Lab where it has been missing, throughout the paper and in the graphic comparing Learning lab with Field school (not highlighted as there are too many instances).

See comment above: How many were international, only four in total (?)

AUTHOR: We have clarified this, but is this additional detail strictly necessary? It takes us beyond the word limit.

See above: For ease of understanding: Use same wording as above, if applicable, e.g. when interviewed, some weeks after the completion etc...

AUTHOR: Wording was changed accordingly, in two places, highlighted in yellow.

Additional information can help: two of the international mentors? Two of how many mentors in total? (are two significant, were these two especially important to the know-how provided during the course?)

AUTHOR: Added: Two of the international mentors, as well as information on the # of mentors. Note that the addition of all this detail is changing the paper towards becoming an evaluation report on the evaluation of the TILL, and away from an academic piece on

This is a very important statement in the text - perhaps try to highlight it more so that it is easier to find within the text...

AUTHOR: We can only hope readers will read all the text. Of course adding a lot more detail also makes it more likely that the point will be overlooked.

Perhaps weaken this statement? Appears to be paramount (?)

AUTHOR: We think it IS paramount and a key difference between the two pedagogical approaches

And when (?)

AUTHOR: Yes. Added “and when” to make it explicit

Clarified (e.g. discussed) (?)

AUTHOR: Added: discussed and clarified

Maybe add the intention, e.g. the diverse contributions, or „the value of the diversity of contributions“

AUTHOR: Added “the value of the diversity of …”

State: why did the students apply? What was the incentive, e.g. if they had already completed their master degrees- or were they „doing“ their master degree, e.g. in a master degree program? Unclear without further research in the stated references

AUTHOR: Added: their motivation to learn more about transdisciplinary research and practice,

These statements are all in a negative formulation, e.g. the learnings are all from shortcomings.

Is there any possibility to reframe it with more positive statements - e.g. does profit from more communication between developers… even more complex than we have anticipated; benefits strongly from shared and ongoing… etc…

A positive formulation might help to avoid the interpretation of your findings as „learning from mistakes“, as you state later in the text. These findings are very important learning experiences from the lab - thus they should come with a positive tone.

AUTHOR: This is true, but this is the actual selected data from the interview transcripts and we will not change it. We have noted that this is a sub-set of the overall data, it is not the comprehensive evaluation report (which in our view would not make for a good academic paper, or at least, is not the paper we wanted to write). We have gained our reflective insights from the analysis of the negative data and hence that is what we wanted to probe and share; that is what we think other scholars can benefit from and also contribute to through their research and reflections. But we have emphasized that there were also many positive findings.

I also think that important contributions of educational scaling research is not mentioned or addressed, contributions that I think could strengthen the evaluation findings.

AUTHOR: Yes, true. We added to the sentence to indicate this (with a reference to Pawson and Tilley whose book deals with scaling). No space to expand.

Thank you for this clear statement - and for the work you put instead into writing up this paper!

AUTHOR: And thank you very much indeed for the close reading and comments you provided.

See figure one for additional comments" please see for necessary correction etc.

Comment on the arrow in the figure: It could be interpreted as that here is only exchange between domain one and three, as it is drawn above domain 2 - maybe improve the representation to show that there should be / is feedback between all domains.

In the text you only refer to feedback between inner domain and domain 2.

AUTHOR: Yes, we re-drew the diagram with 2-way arrows from each domain to each of the others. (New Figure 3)

Maybe try to include something like „exploring“ here - that educators should still, although they can be very experienced in their field, think as explorers or in an exploring way about the educational path/journey they are going to design for/with their students… It seems appropriate do develop a mindset of exploration, as transformation seems to be by definition a rather unexplored task
AUTHOR: Yes. Added “exploring innovation and …”
Before stating the findings in the abstract, the authors need to describe the methodology and tools used to generate and analyse data.
AUTHOR: Done (marked with yellow highlight)
I propose this title: Evaluating innovation in transdisciplinary sustainability education: The case of TRANSECTS’ International Learning Labs
AUTHOR: This is definitely a better title, yes. However the SAJS has a strict word limit that does not allow us to add “The case of …”
Possible to add references to this claim, e.g. a literature review. However, adding references in "significance section" might not be mandatory.
AUTHOR: Not appropriate to add references in the “Significance” section - Editor to advise.
I am satisfied with the literature review with the concepts discussed. I however feel the authors could have included a discussion on transformative learning or what they call “transformative sustainability education”.
AUTHOR: We were mindful that other submissions to this SI were most likely to expand on this, and given the word limit, we felt we could just state the most pertinent points that are relevant to the paper. We have now added references and expanded on our earlier points, which do unfortunately add to the word length and also create some repetition. We would like Editorial guidance on this, as we are not privy to the status of the other papers submitted.
This part of the sentence appears unclear - suggestion to rephrase for clarity, e.g. break up into two sentences.
AUTHOR: Done - two sentences with clarification.
You focus here on interest, but as your experience has shown, it is also important to reflect on their different backgrounds both in e.g. academic discipline as well as perhaps in culture. Could you add this thought already here?
AUTHOR: Added
A reference for this statement seems appropriate, e.g. use reference from above again, if possible.
AUTHOR: Added the Funnel and Rogers reference which covers this.
To stay in your mindset of evaluation and evolution: Could the key question as well shift within a TILL-Lab due to more insights? Would it be thus better to keep even the „key question“ to a reasonable extend „fluent“ during a TILL? This would be very different to a classical approach of hypotheses-driven scientific research which works with iterations and refinements, but not with being fluent.
AUTHOR: Yes. We have subsequently considered that the TILL can start with a given question, that comes from the BR practitioners in collaboration with TILL hosts; when students arrive they start exploring this question but it is somewhat fluid and after some time (we have not concluded how long) they can present a revised question, based on their initial exploration of the context, from their diverse disciplinary backgrounds. We had this idea from Alex Baumber at University of Technology Sydney where this is part of their TD training. The BR partners are however clear that questions arise from long-standing, trusting relationships and students cannot be expected to develop these during a relatively short learning programme.
Mentioned already above: State duration of TILL 2023 as important additional information to the reader
AUTHOR: Information on the duration of the TILLS added to the early description.
The methods section is a weak point in my opinion. The authors should describe the methods of data collecting and data analysis. There should be absolute clarity on how they arrived at their findings, e.g. how did the authors arrive at the “three domains of change” line 195? Overall, this proposed publication puts together a useful case of transdisciplinary learning and research that

will be relevant to a wide range of sustainability education practitioners internationally. There will be need for clarity at several points. I have made some comments and concrete suggestions in tracked changes on ways the chapter can be improved

AUTHOR: The three domains of change are part of the Theory of Change developed on the basis of the programme document, this is now hopefully better explained.

We have made several changes to the Methodology section, as detailed in response to Reviewer 1, who had a similar concern.

Reviewer B: Round 1
Date completed: 10 April 2024
Recommendation: Accept / **Revisions required** / Resubmit for review / Decline
Conflicts of interest: None

Does the manuscript fall within the scope of SAJS?
Yes/No
Is the manuscript written in a style suitable for a non-specialist and is it of wider interest than to specialists alone?
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Yes/Partly/No
Please rate the manuscript on overall contribution to the field
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Yes/No
Are the results and discussion confined to relevance to the objective(s)?
Yes/No
The number of tables in the manuscript is
Too few/Adequate/Too many/**Not applicable**
The number of figures in the manuscript is
Too few/**Adequate**/Too many/Not applicable
Is the supplementary material relevant and separated appropriately from the main document?
Yes/No/**Not applicable**
Please rate the manuscript on overall quality
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Is appropriate and adequate reference made to other work in the field?
Yes/No
Is it stated that ethical approval was granted by an institutional ethics committee for studies involving human subjects and non-human vertebrates?
Yes/No/Not applicable

If accepted, would you recommend that the article receives priority publication?

Yes/No

Are you willing to review a revision of this manuscript?

Yes/No

Select a recommendation:

Accept / **Revisions required** / Resubmit for review / Decline

With regard to our policy on 'Publishing peer review reports', do you give us permission to publish your anonymised peer review report alongside the authors' response, as a supplementary file to the published article? Publication is voluntary and only with permission from both yourself and the author.

Yes/No

Comments to the Author:

Dear Author(s), I really enjoyed reading your report. I have made some recommendations, but would like to point out above all that you should think about whether the title is really the best representation of the content. That said, it was (tragic) fun to read the manuscript - it really pointed out insights (mistakes) that don't seem to be uncommon in multi-stakeholder educational settings - and provided a possible solution to them. Very well worth reading it and thanks for your efforts to write it up! Good luck with your next iterations of the TILLs.

I have to state that I found reading this report very interesting. This is due to the fact that it does not only highlight a common problem experienced when working together with multiple stakeholders with a) various backgrounds and b) who do not know each other and the working style beforehand. As a) and b) are quite common in the area of designing innovative interdisciplinary educational formats, the findings will be of interest to a wider audience.

However, the report also provides first steps into a solution of the described common dilemma, and this solution can be implemented without a huge extra effort. Thus, it does provide support for the problem it identified and has practical value.

I did not rate this manuscript "excellent" in overall quality due to a (subjective) shortcoming at the starting point of the ToC-design. As I read the manuscript from start to end (and thus not flipping through it in the usual way Abstract / Conclusion / Method / Intro...) I did draw exactly the double arrow already in figure 1 as is provided later in figure 3 - meaning that the initial ToC-design seems to be based on a rather simplifying approach with its linear impact model. However, I do realize that this impact model is often implicitely used when no ToC-model is designed or discussed between partners - and therefore highlighting to think more about the feedback-loops in educational processes is very important.

That said, it was (tragic) fun to read the manuscript - it really pointed out insights (mistakes) that don't seem to be uncommon in multi-stakeholder educational settings - and provided a possible solution to them - very well worth reading it!

[See Appendix 2 for Reviewer B's comments made directly on the manuscript]

Author response to Reviewer B: Round 1

Above all you should think about whether the title is really the best representation of the content.
That said, it was (tragic) fun to read the manuscript - it really pointed out insights (mistakes) that don't seem to be uncommon in multi-stakeholder educational settings - and provided a possible solution to them. Very well worth reading it and thanks for your efforts to write it up!

AUTHOR: We have tried some other options but concluded that this title captures what we want to say.

In the sense that the TILL cannot by any means be described as a failure or a mistake, we do not necessarily agree that the experience was a tragedy; we share the view that practitioners who reflect on the outcomes of their endeavours have a better chance to do (even) better next time! Reflective practice is regarded as 'best practice' in the educational sciences but indeed, not always as common as we know it should be, given time constraints, unwillingness to be associated with 'failure', and so on.

We further believe there is some element of analysis in the work presented here and as indicated, therefore do not merely regard it as a report, but as a research paper. This further speaks to the value, in our view, of reflexive practice.

I did not rate this manuscript "excellent" in overall quality due to a (subjective) shortcoming at the starting point of the ToC-design. As I read the manuscript from start to end (and thus not flipping through it in the usual way Abstract / Conclusion / Method / Intro...) I did draw exactly the double arrow already in figure 1 as is provided later in figure 3 - meaning that the initial ToC-design seems to be based on a rather simplifying approach with its linear impact model. However, I do realize that this impact model is often implicitly used when no ToC-model is designed or discussed between partners - and therefore highlighting to think more about the feedback-loops in educational processes is very important.

AUTHOR: Yes, the way in which we conceptualized and worked with the Theory of Change (ToC) was not very clear in the paper, thank you for encouraging us to do something about that. We have now added the original ToC (from the proposal) which is an tabular log-frame (as a new Fig 1), and compared the original Fig 1 (now 2) with it, to indicate that while the concentric circles diagram was not necessarily linear, it could still be interpreted as such, and was to some extent, at least some of the time. Hence the need to make the two-way learning more explicit, which we now make more explicit in the text as well as with multiple double arrows in the new Fig 3 (former Fig 2).

Reviewer I: Round 1

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Evaluating innovation in transdisciplinary sustainability education: TRANSECTS' International Learning Labs

Abstract

Programme evaluation can advance sustainability education through the learning it can enable, at micro and systems levels. This proposition is explored by examining evaluation practice in a six-year international programme entitled Transdisciplinary Education Collaboration for Transformations in Sustainability involving universities and biosphere reserves/regions in Germany, South Africa, and Canada. A Transdisciplinary International Learning Lab (TILL) offered in 2023 was evaluated using a theory-based evaluation approach, followed by a meta-reflection among programme developers. We found that our TILL had elements of a Field School, rather than a Learning Lab; and that our curriculum development and delivery required more explicit deliberation among us, towards a deeper and shared understanding of pedagogical assumptions, and more congruent practice of transdisciplinary and transformative sustainability education in higher education. A theory-of-change based approach enabled learning from evaluation. The paper is an invitation to other innovators in sustainability science, education and evaluation, to share related findings.

Significance of the Main Findings

Through reflective practice based on evaluative research, the designers of a sustainability education programme gained insight into how the concepts of transformative education, transdisciplinarity and evaluation play out in practice, and how programme evaluation can foster learning and inform ongoing and more transformative programme design. As higher education practitioners collaborating across continents and disciplines for systemic change, we noted that transformative concepts do not immediately translate into transformative practices, unless we critically and collectively reflect on practice and outcomes. Such (meta) reflection requires data and purposefully designed evaluation frameworks-in-use. This idea is not new, but its manifestation in practice was illuminative, and could also be significant for other curriculum and evaluation designers.

Introduction

TRANSECTS[1,2] is a multi-year, international programme entitled, Transdisciplinary Education Collaboration for Transformations in Sustainability, at the intersection between universities and UNESCO Biosphere Reserves. In sustainability education, there is a quest for

innovative curricula that engage participants in potentially transformative experiences, through which to learn not only how to analyse complex sustainability challenges, but also how to work together towards solutions[3,4]. It is for this reason that TRANSECTS offers Transdisciplinary International Learning Laboratories (TILLs) on three continents.

TRANSECTS situates its TILLs in Biosphere Reserves (regions in Canada; hereafter BRs), these being characterized as "model regions" for sustainability, and an important governance, practice and learning space in complex social-ecological landscapes. The programme invites graduate students to join BR managers in exploring issues experienced in these landscapes, with the aim of developing competencies for sustainability practices.

The TILLs themselves, though interesting as curriculum innovation in sustainability education, are not the main focus of this paper; rather, we share here a reflection on the use of the framework which the authors designed to *evaluate* the TRANSECTS programme[5], including the TILLs[6]. Analysing the use of the evaluation framework to deepen innovative practices is interesting – and a research paper rather than simply an account of practice – because of the manner in which theoretical concepts of sustainability science, transformative higher education and transdisciplinarity[7] are encoded in the framework, and already in the first two years of implementation, informed and deepened by its application.

Context and Literature

The need for pedagogical innovation in higher education

The need for higher education innovation is explored more fully elsewhere in this Special Issue, but one consideration is pertinent here: that universities' responses to sustainability challenges must include pedagogical innovation. It cannot suffice to simply introduce new subjects or new content in existing subjects. Higher education *has* to catalyse and enable *new* ways of thinking, valuing, and doing, which may require un-learning of sedimented patterns of value, thought, and practice, and the development of new habits. Such transformative learning does not simply result from exposure to new information. Learners need opportunities to grapple with existing values and practices, including their own, without becoming defensive or despondent; they need spaces in which to practice working out solutions, and real opportunities to take actions, big or small. Responding to sustainability concerns requires multiple actors to work together, and the skill of enabling collaboration[3]. In complex sustainability contexts, the role-players are many and have diverse and often conflicting interests. Educators have thus been proposing concepts like agency[8]; action

competence[9]; interpersonal and sustainability competencies[10]; intercultural competencies[10,11]; technical and transformational leadership skills[12], relational and transformational[13] and reflexive competence[14]. Various curriculum and pedagogical innovations that encourage 'active learning'[15] have been proposed, from project work in schools to multi-step social learning processes in industry[16] and the Learning Lab, which was the pedagogical innovation of choice for TRANSECTS. A Learning Lab (also Challenge Lab or Living Lab) is an educational opportunity created for students to engage with a sustainability challenge outside the academy, which is usually multi-facetted, requiring analysis from different disciplinary and non-disciplinary (e.g. Indigenous knowledge) angles. In the Lab the problem is probed through research and stakeholder engagement, and solutions are developed and/or explored, and even tried out to start a further cycle of reflection and development[17]. There are many methods for this[18].

The TRANSECTS programme

The TRANSECTS programme was initiated by collaborating universities in Canada, South Africa and Germany, with the lead partner and main funder in Canada. Implementation activities commenced in 2022. These include a series of Transdisciplinary International Learning Labs (TILLs) – one each year; and annual Programme Institutes, where partners (academics, practitioners and students, from universities, BRs and elsewhere) come together to network, share, reflect, learn and plan.

The team conceptualising TRANSECTS (which includes the authors) also produced an evaluation framework to track, reflect and report on the programme processes, outcomes and impacts over its envisaged six year lifespan. As TRANSECTS is about innovation and transformations in sustainability, we aimed to design a congruent and innovative evaluation framework, to support the transformative intent of the programme, and to optimise ongoing learning.

Evaluation approaches

When energy and resources are invested in a programme of interventions, courses and resources, evaluation is essential – not just at the end, to satisfy both funders and implementers that this was a worthwhile investment, but also along the way, so as to pick up emerging issues and respond effectively, to improve the programme and its chances to achieve desirable outcomes. Evaluation itself can be costly, and deriving optimum value from it would include *learning*, among programme participants and across multiple evaluations, in the field as a whole[19].

Theories for programme evaluation have undergone shifts over time, that match paradigm debates in broader social science research methodology[20]. Evaluation theory shifts encompass various responses to the observation that educational processes and social change are complex, non-linear, and seldom easy to capture through simple pre-test, post-test measurements[21]. Much has been written about the limitations and negative consequences of imposing an 'experimental vs control group' evaluation design as the 'gold standard', onto non-linear social interventions in complex systems[21-23.] Alternative approaches have been proposed, to evaluate for example programme processes and development[21,22], values and narratives[24], principles[25] and open-ended value creation[26] or identifying the underlying mechanisms that give rise to change[20].

Associated with the latter approach is theory-based evaluation[27]. An early proponent was Weiss[26], who proposed that in order to evaluate a programme of interventions, it is necessary to articulate the programme theory, thus surfacing the designers' theory of how change is likely to come about (theory of change) and their theory of action, explaining why the intervention actions might effect that change. The goal is to evaluate the programme according to this explicit theory, in such a way that the evaluation findings both indicate *whether* the desired change has taken place, and, since there is then also an opportunity to interrogate the programme theory itself, to explain *why* this change happened, or not[30].

All programmatic interventions are typically based on a theory of some kind, and most evaluations proceed from a theory of change. These theories are, however, seldom explicit[21]. For example, the commonly used 'logical framework' embodies a programme theory or logic: If *these* activities are undertaken with *these* inputs, then *these* outcomes will eventually lead to *this* desired impact. *How* X is going to lead to Y, is seldom explained. Thus the recommendations[27,22,23] to start an evaluation with the articulation of an explicit theory of change (involving the programme designers and implementers themselves), from which indicators are derived to guide what should be monitored; what data should be collected; and how it should be evaluated. This 'theory' should be open to review, with evaluation creating a feedback loop from which implementers can make not only adjustments to the implementation processes, but also re-think their theory of change. Where necessary, implementers can then revise it, and associated indicators, accordingly. The approach shares the intent of strategic adaptive management[29] and also draws on theories of *deeper*, *higher* or *triple loop* learning (see X and X, this issue).

This theory-based approach was followed in the conceptualisation of the TRANSECTS programme evaluation.

Evaluation framework and tools for TRANSECTS

TRANSECTS' programme designers produced a standard tabular log-frame about the relationship between programme inputs, outcomes and impacts, but also a non-linear graphic version (Figure 1), to identify three change domains that were of interest: *participants' learning*, but also how *institutions* support transdisciplinarity; and research and engagement *practices* in the BR landscapes; possible relations among these three change domains, and the direction of change (arrow in Figure 1).

This simple version of TRANSECT's proposed 'pathways to change' (another way to refer to a theory of change articulated for evaluation purposes) left out most of the details in the tabular logframe, but hypothesized some relationships. Figure 1 suggests a degree of non-linearity in that the sphere of higher education innovations in the centre, will ripple out in many and perhaps unforeseen ways to encourage participants' learning in the central sphere, which would in turn in many and perhaps unforeseen ways ripple out into changed research and engagement practices in BRs, represented by the broadest sphere on the outside of the graphic. The general direction was presented (and conceptualised) as from the academy, through the learners, to the field.

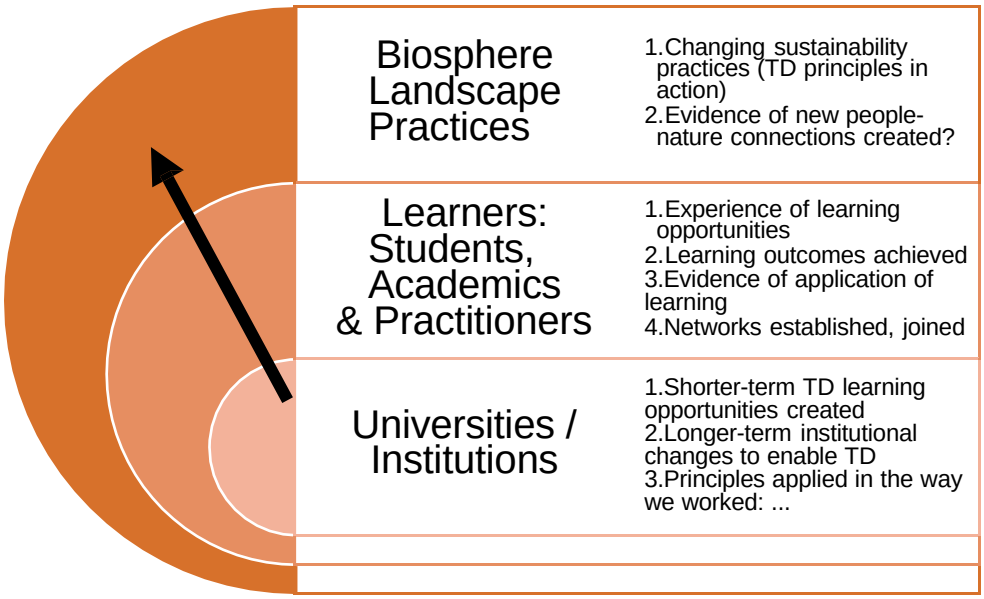

Figure 1: TRANSECTS' Theory of Change

In the initial stages of programme implementation, somewhat constrained by time and distance (over three continents), the design of the theory of change was neither extensive nor fully inclusive. Nonetheless, there was support for the theory of change. Implementers also agreed that it would be open to change so that from time to time, it should be reviewed and the selected evaluation indicators, instruments and processes adjusted accordingly.

This is standard practice, at least according to theoretical descriptions of theory-based evaluations. An evaluation process based on an explicit, non-linear and evolving theory of change is, however, a departure from the norm in programme evaluation. The MEL team thus undertook to monitor the evaluation framework itself, as it unfolds in-use. TRANSECTS is funded as a capacity building programme, rather than a research programme, but through the theory-based framework, research was built into its evaluation processes, using the theory of change, data collected from evaluating implementation activities, and periodic meta-reflections on emerging findings. This research methodology is described next, as it produced the findings on which this paper is based.

Methodology on which this study is based

Using the theory of change diagram, planned programme activities were entered in the three domains of change, with associated evaluation questions, and instruments to gather data about those activities where then designed. Broadly, we asked:

- whether activities were executed as planned and according to TRANSECTS' principles[2]
- whether desired learning outcomes, derived from literature in the sustainability sciences and education, were achieved and applied[3,10]; and
- any other outcomes that emerged and seemed relevant to TRANSECTS' transformational intent.

Implementation activities at the start of TRANSECTS focussed on new courses and TILLs in the central 'higher education institution' domain of change, offered to students in the 'participant learning domain'. Two TILLs were offered in Germany, starting with a pilot in 2022. Both TILLs were evaluated, but the 2023 TILL was evaluated more comprehensively,

by both internal and external evaluators. The 2023 TILL and a sub-set of its evaluation findings form the basis of the meta-reflections in this paper.

As the planning of the 2023 TILL rolled out, requiring extensive logistics and communications across three continents, and involving hosts, mentors, and student participants from an even larger number of universities, the Monitoring, Evaluation and Learning (MEL) team designed evaluation instruments and processes for the TILL. These consisted of:

- questionnaires sent to participants prior to, during, and on conclusion of the TILL
- focus group discussions with participants during and after the TILL
- review of student assignments
- focus groups (student feedback and discussions) some months later, during Programme Institutes
- interviews with TILL students
- interviews with TILL mentors on conclusion of the TILL
- interviews with BR practitioners.

An external evaluator conducted some of the focus groups and interviews, and other evaluation activities were undertaken by TRANSECTS MEL team members, including authors of this paper. Interviews and discussions were either in person or online.

Ethical clearance was provided by the [institution anonymised]. Data are stored in a secure Microsoft Teams depository; only TRANSECTS contributors who have completed research ethics training can view the data or engage with participants for evaluation purposes.

In addition to on-site data collection in Germany, some months later students who participated in either of the TILLs shared feedback with mentors and programme staff during a Programme Institute in South Africa. Members of the programme design team who were present then engaged in informal meta-reflections on this feedback and other data that had been collected and analysed. During reflections we applied inter-subjectivity as a means to bring objectivity to our process[31], that is, we challenged each other's interpretations and when found to be sound, built on them. This included a later online engagement with TILL hosts.

In the next section we share the selected findings and meta-reflections that form the core of this paper. Our data sources revealed that while the TILL was a worthwhile learning

experience for students, and highly rated, in some ways we as a collective fell short of offering the innovative, *transdisciplinary* learning experience we had intended. Our evaluation framework-in-use explained how this might have come about, and these insights can inform wider systemic learning.

Findings

The 2023 TILL took place in mid-winter in a BR in a rural region of Germany. Its focus was on different forest ownership types, with different management objectives (optimum yield vs biodiversity, for example). The students were graduates, most with Masters degrees, from universities across the three continents, selected on the basis of their academic and leadership abilities, and with a variety of disciplinary backgrounds. They stayed in shared accommodation and, for part of the TILL, had to plan and shop for shared meals. Outdoor excursions and meetings were arranged where forest scientists shared their expertise.

Configuring the TILL involved many more role-players than the hosts. Six weeks before the in-situ TILL, students were engaged in a Foundational Course, a series of customised online orientation sessions and seminars, including presentations on transdisciplinarity by academics, and an introduction to Constellation Analysis[32] as a potential transdisciplinary method for analysing complex sustainability challenges and for identifying entry points for strategies and their systemic effects. Three international mentors were appointed, for the first two weeks of the TILL, along with local mentors and instructors.

Despite concerted efforts to involve them, TILL mentors were not all able to attend all the orientation sessions, and the BR managers found it particularly difficult to attend, possibly due to connectivity, language barriers and time zones. This difference between the orientation of the students, and the limited orientation of TILL hosts and mentors, could well have been significant in what unfolded.

Findings: Students' experiences and views

When asked, during and after the TILL, to reflect on their experiences, students noted (among other, some very positive, observations) that:

- The actual problem to research was not clear at the start
- How to contribute from their particular disciplines was also not clear, particularly at the start of the TILL
- Relationship with BR was not clear; were the students meant to be consultants or even free researchers for the BR?

- Living together and working with others' differences, was hard for some
- A deeper understanding of transdisciplinary developed
- Students learned much and will highly recommend a TILL to others, but with some changes, e.g. stronger transdisciplinary dimensions and learning mediation.

Findings: Mentors' experiences and views

When interviewed, some weeks after the completion of the TILL, and asked to reflect on their experiences, mentors noted (among other observations) the following:

- The use of transdisciplinary methods during the TILL was not explicit
- Mentors were not always clear on the problem to be researched, or on who should determine the question – students, mentors or BR managers
- The role of the BR managers was not always clear
- The scope of the mentoring was not always clear; to what extent should they steer students, and which aspects of the TILL should they facilitate or support?
- Dealing with interpersonal conflicts was stressful for some mentors who felt unprepared for it
- Mentors would recommend more TILLs (and want to be involved in them) with some changes including more explicit structure and purpose.

Findings: BR practitioners' experiences and views

When interviewed some weeks after the TILL, to reflect on their experiences, BR practitioners noted (among other observations) that:

- The start of the TILL was too unfocused
- Some students had surprisingly little interest in forest ecology
- The BR's roles viz those of the mentors were unclear
- Students were well equipped with technical knowledge to complete set tasks, but more conceptual guidance was needed to bring out conservation and governance aspects
- The quality of the assignments presented by the students to the BR at the end of the TILL, was good.

Another key finding is that when COVID struck during the first week of the TILL, two mentors left the site and proceeded to attempt mentoring online; some students and remaining mentors experienced this as a significant gap in support.

Findings: Programme developers' meta-reflections at the Programme Institute

During the 2023 Programme Institute in South Africa, the authors considered the data collected and analysed thus far, and asked meta-reflection questions which could be summarised as:

- What pattern are we seeing in the data and feedback from TILL participants?

- What actually happened in the TILLs versus what was intended?
- Why did this happen? What could have given rise to these outcomes?

We concluded that as a collective, we may have conceptualized and approached the TILL more as a Field School, than as a Learning Lab. In sharing with each other what we understood to be the differences between these two curriculum offerings, we found this conclusion to be a sound and powerful explanation for what transpired, that resonated with all of us, and with TILL mentors, when we later engaged them.

In the discussion below we reflect on why this conclusion is warranted, and significant for transdisciplinary and transformative approaches to sustainability education – in relation to TRANSECTS (micro-level) but also to wider theory and system building; a building process that is needed, as argued elsewhere in this Special Issue. We also explain the relationship between the evaluation processes, and our learning.

A summary of the findings from the meta-reflection, is that we learned that transdisciplinary curriculum development for transdisciplinary learning labs across different contexts is:

- more complex than we had anticipated;
- requires more communication between curriculum developers, and between developers and implementers (such as TILL hosts and mentors); and
- requires shared and ongoing clarification of transdisciplinary and pedagogical approaches.

As a collective, we had either misunderstood or under-estimated what transdisciplinary education innovations require, as we elaborate next.

Discussion: Reflection and Elaboration

What is a Field School, and what is a Learning Lab? What are the differences between them, and why did we think that we have in some ways approached the TILL more as one, rather than the intended other?

Drawing on the literature on Learning Labs and Challenge Labs[4,13,32-33] and our experience as higher education practitioners in the Geographical and Sustainability Sciences, Higher Education Scholarship of Teaching and Learning, and Environmental Education, of Field Schools (the term used in Canada) or field trips (the term used in South Africa), we identified a few key differences related to purpose, process and end-points (Figure 3).

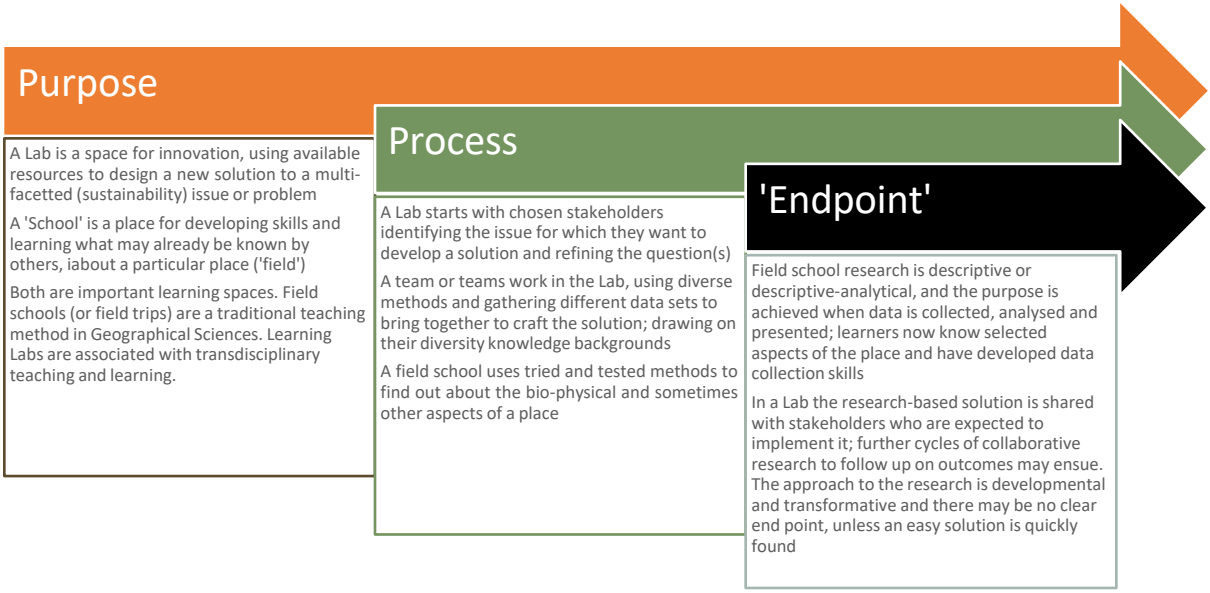

Figure 2: Differences Between Field Schools and Learning Labs (author generated)

The authors realized that the *purpose* of a Learning Lab, to collaboratively work towards a solution for a problem that has also been jointly identified and explored, and share that solution with each other, and possibly a broader range of stakeholders, should have been made clearer to BR hosts, mentors and students. Throughout the TILL, learning should have been mediated with references back to the Foundational Course and the theoretical discussions on transdisciplinarity. The gap left by the early departure of two of four mentors signalled just how important learning support was, not only during the first two weeks, in fact, but throughout – something that was not fully anticipate when the Labs were conceptualized.

Similarly, the contributions of graduates with backgrounds in Politics, Economics, Education, Governance, Forestry, Agricultural Sciences and Ecology, should have been more apparent to all. Students were not attending to simply collect field data as free research assistants. The relevance of inputs from a top Ecologist in relation to the sustainability issue under investigation, should have been clarified, and not assumed, or assumed to be the most important or only input needed.

Learning Labs (and a transdisciplinary process like Constellation Analysis[31]) start with the identification or elaboration of a sustainability issue through stakeholder engagement, because the process of formulating the central problem and associated research question(s) *with* stakeholders (in this case BR practitioners, other forestry owners and neighbours) is paramount and not simply a precursor to the research. Thus, Transdisciplinary Learning Labs require ample time and opportunity for stakeholder engagement.

Lab participants should agree that the key question(s) to research might not be clear at the start; however there should also be an agreed-upon process for concluding what would be the most relevant question to research. This is a fundamental aspect of transdisciplinary work – not just a preliminary step to quickly get out of the way, or to be handed down before the start of the Lab. In the 2023 TILL students, mentors and BR practitioners were either unclear as to what the key research question was, or unclear about how it was to be derived, and by whom.

In some ways we approached the TILL like a Field School where the focus is usually on collecting bio-physical data, for example, by not fully anticipating the requirements for stakeholder engagement. An example is that the majority of BR stakeholders spoke only German, which only a few students could speak, leaving the majority of students unable to directly engage with stakeholders.

We also realised later that students needed to hear explicitly that challenges experienced around living together (deciding between meat or vegetarian meals, for example) were an integral part of the intended learning outcomes. Relational[13] or interpersonal competencies[11] are prerequisites for solving sustainability challenges with others. TRANSECTS proposed to develop intercultural competencies by selecting graduate students from different disciplinary, language, cultural and ethnic backgrounds and nationalities to participate in the TILLs. Resolving the challenges of working across such differences, and using the diversity optimally, are key to successfully addressing complex social-ecological issues[3,7]; however, we did not anticipate just how steep this learning curve would be and that TILL participants would need *ongoing and expert facilitated learning mediation* in this regard. On reflection we realized that our approach to the TILL was predominantly resource-based (asking what resources we have and how best to use them) with less attention to coherent curriculum design.

Mentors were uncertain about whether or how to address the intercultural challenges that emerged. On a field trip, such conflict and taking time to resolve it, is simply a by-product of

the primary focus on co-habiting in a remote area in order to (learn how to) collect separate pieces of bio-physical information. In the case of a Learning Lab, however, 'finding' each other (across disciplinary and cultural boundaries) is a key success factor for working together to address a complex problem. Resolving the problem not only requires participants to communicate and work together, but also to fully appreciate and use each other's diverse contributions. Mentors felt ill-prepared to facilitate conflict resolution; it did not feature in the 'job description', and requires skills they either felt they lacked or were not primed to draw on. While mentors and students alike reported that students eventually found peace and even joy in their differences, we collectively missed the opportunity to make the importance of relational competencies[3] explicit, and to provide scaffolding to strengthen learning.

In a field school, mentors have particular roles: providing instruction about data collection, assisting with technical aspects, perhaps socialising after-hours with students so as to help induct them in the field, and assessment of tasks completed. Roles were less clear in this Lab. What was their role in relation to the setting of the research question, stakeholder engagement, transdisciplinary research skills, and interpersonal conflicts? The evaluation suggests that there was a need for more explicit learning mediation along the way – that the TILL could not be left to unfold without regular feedback to the students, with reference to the intended learning outcomes, and a recommended suite of transdisciplinary engagement methods from which to choose.

At this point it should be noted that the TILL was by no means a failure. It had many positive features and outcomes. For example, the students' final assignments were of good quality and well received by academics and BR practitioners alike; several students wish to attend the next TILLs as mentors; mentors have offered to participate in future TILLs; and new relationships between BRs and universities were being forged as a result of the shared endeavour. Given such successes it would in fact have been easy for us to overlook the fact that the curriculum offering was *in some ways* simply a more ambitious version of what we would have offered in the past (a field school) rather than the fundamentally different intervention (a transdisciplinary learning lab) we had theorised it to be.

Why, despite good intentions, did we not entirely achieve the intended curriculum innovation? The fact that we were a multi-disciplinary, multi-lingual team spread across three continents and time zones, may have had much to do with this. Opportunities to develop a shared conceptualization of the TILL, such as online meetings, could not be optimally used due to these constraints. But members of the team who regularly interact with each other and had, on the surface, shared understandings of the nature of the innovation, also approached it quite

differently. Disciplinary differences might have had a role in this, and thus it is an instructive example of the situations that transdisciplinary practitioners (including our graduates) find themselves in, in the complex social-ecological landscapes of practice. We also noted that students and mentors *had* been briefed about the ways in which the TILL was to be transdisciplinary … and we can only conclude, retroductively, that transcending years of excellent disciplinary training, was not going to be happen in an instant – unless one applies these ideas in practice, and reflects on them, as we attempt to do here, on an ongoing basis.

In response to the evaluation findings, the TRANSECTS programme designers subsequently took a number of steps to strengthen the planning of future TILLs, including more explicit curriculum planning; assigning and clarifying pedagogical roles for TILL mentors and hosts; careful consideration of the ways in which the proposed TILL focus and research question(s) lend themselves to transdisciplinary and engaged research and innovation; and adjustments to the Foundation Course, which will include evaluation insights. A follow-up Program Institute in Canada dedicated several workshops to flesh out the distinction between a TILL and a field course by determining how to align learning outcomes with activities and assessment for future learning labs.

The findings also effected adjustments to TRANSECTS' theory of change: change does not only take place among learners in the second domain of change; change has to also take place in the central domain *where we as higher education institutions need to change the way in which we conceptualize, design and deliver our curriculum offerings*, based on feedback from the field. This feedback loop and learning would not have been possible, without evaluation, specifically the theory-based evaluation process we followed.

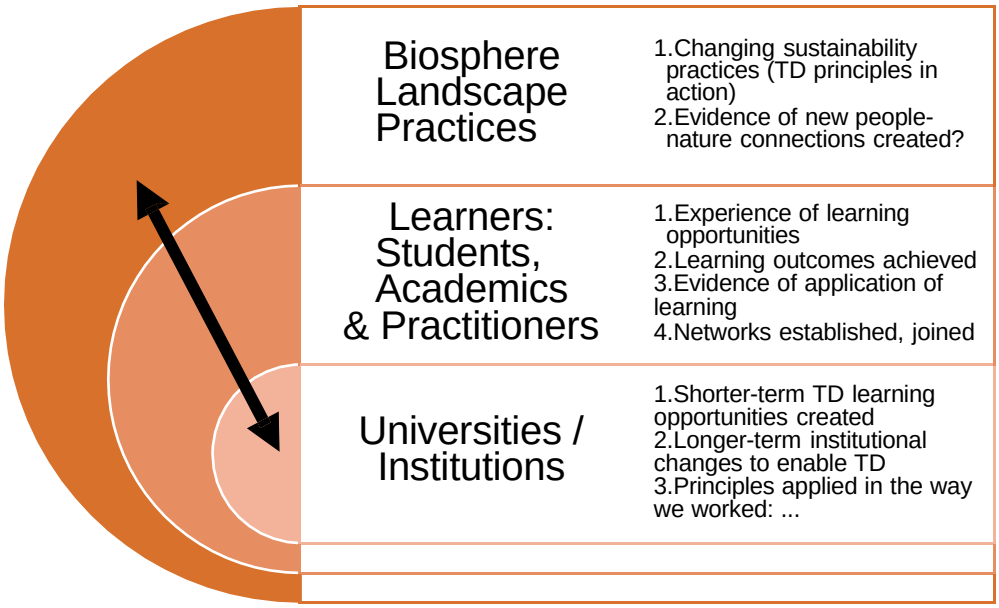

Figure 3: TRANSECTS' slightly revised Theory of Change

As noted earlier, theory-based evaluation[25-26, 28-29] starts with articulating an explicit theory of change from which to derive indicators that guide what data should be collected; and how it should be evaluated.[21,27-28] This theory must be open to review, and evaluative practices should create a feedback loop from which implementers not only refine implementation, but also, where necessary, re-think their theory of change and revise it, and the associated indicators. In this case, we have added evaluation of the process of TILL development to track the extent to which we are designing for transdisciplinarity. Thus the network of learners includes not only graduate students, but also BR practitioners and higher education academics. We had initially indicated this when conceptualizing TRANSECTS[1], but are now clearer on how this learning can happen.

The use of a non-linear theory of change[21,28] influenced the way findings were processed, as it encouraged us to be reflective practitioners that *look across the data* of practitioners, mentors, and graduate students, given that our theory of change presents the relationships between these domains as important but as yet under-theorised. Focus group, interview, and questionnaire data established some common themes: roles were unclear, and cultural practices, previous experiences with transdisciplinarity, and understanding of what a TILL needed to be in order to optimize learning, shaped unarticulated expectations. In troubling the connections between each domain in the theory of change, across the network of

learners, we realized the extent to which the “learners” included those organizing and leading the TILL. The theory of change afforded deeper thinking than if we had simply counted numbers of participants, or checked whether learning outcomes had been achieved. The educational change process was organic and dynamic, and the theory of change reflected this reality.

The results of evaluation-in-use include deeper iterations of the program theory, notably the distinctions between a more standard field school and what a transdisciplinary and intercultural Lab was intended to do. These insights arose from returning to the expected flow in the theory of change and discussing what evidence indicated about it and why.

The process also resulted in more concrete programme changes, like the redesign of the Foundational Course and the TILL. Ultimately, some of the best evidence of strong evaluation is the capacity to use it in situ[20] to make changes iteratively. A simple, but significant, flow of the key elements for students, practitioners, and mentors made it easier to remember programme goals and engage in deep conversations around what the evidence indicated, without the limitation of a narrower focus on specific outputs or structures of a standard logic model. Working reflexively with a theory of change proved even more significant given the number of people involved in the evaluation, communicating across time zones and cultures, and complex TILL experiences.

Thus we confirm the value of theory-based evaluation and working iteratively with a programme theory. As Oberlack et al.[35] argued:

> ToCs trigger debate among the stakeholders and evaluators of an initiative regarding the hypothesized and observed effects of actions as well as regarding underlying assumptions about how change happens. Therefore, they can strengthen the effectiveness of research, practice, and education in sustainability science.

Our study shows that a theory of change approach to evaluation can catalyze not only a more rigorous evaluation focused on the change process, but it can also frame and catalyse the kinds of relational, and deliberative processes needed to collaboratively make sense of evaluation data and insights, and to make improvements to an on-going program.

Conclusions – The role of evaluation in developing transformative higher education curricula

When one of us shared the outcomes of our evaluative meta-reflection at a conference that invited delegates to explore “bridging theory and practice” the moderator congratulated TRANSECTS on being prepared to share and learn from our “mistake”. The term “mistake” was surprising and served as a reminder that reflective practices – doing and then learning from reflecting on doing - is not a common practice in higher education. The drive for sustainability transformations should surely be characterised by experiments and innovations in which the term “mistake” might not be the best way to describe practice requiring further refinement; there is now more than ever a need to adopt more critically evaluative ways of working. The paper provides one example with an evaluation framework and process that yielded both data and insights; and thus also the evidence that evaluation, if approached as a form of theory-driven and data-informed feedback, can assist sustainability practitioners to deepen their insights and improve their practice.

The paper provides insight into how concepts of transformative sustainability education play out in practice, just how difficult it is to develop a common strategy for transdisciplinary work, and how evaluation can inform more transformative programme design, implementation and learning for *all* participants. As higher education practitioners collaborating across continents and disciplines for systemic transformations in sustainability education and practice, we learned that transformative concepts do not automatically turn into transformative practices, unless we collectively and critically reflect on outcomes. Such (meta) reflection requires data and congruent evaluation frameworks-in-use. While this idea is not new, its manifestation in practice was illuminative, and we have already seen that other curriculum and evaluation designers also find it insightful.

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Evaluating innovation in transdisciplinary sustainability education: TRANSECTS' International Learning Labs

Abstract

Programme evaluation can advance sustainability education through the learning it can enable, at micro and systems levels. This proposition is explored by examining evaluation practice in a six-year international programme entitled Transdisciplinary Education Collaboration for Transformations in Sustainability involving universities and biosphere reserves/regions in Germany, South Africa, and Canada. A Transdisciplinary International Learning Lab (TILL) offered in 2023 was evaluated using a theory-based evaluation approach, followed by a meta-reflection among programme developers. We found that our TILL had elements of a Field School, rather than a Learning Lab; and that our curriculum development and delivery required more explicit deliberation among us, towards a deeper and shared understanding of pedagogical assumptions, and more congruent practice of transdisciplinary and transformative sustainability education in higher education. A theory-of-change based approach enabled learning from evaluation. The paper is an invitation to other innovators in sustainability science, education and evaluation, to share related findings.

Significance of the Main Findings

Through reflective practice based on evaluative research, the designers of a sustainability education programme gained insight into how the concepts of transformative education, transdisciplinarity and evaluation play out in practice, and how programme evaluation can foster learning and inform ongoing and more transformative programme design. As higher education practitioners collaborating across continents and disciplines for systemic change, we noted that transformative concepts do not immediately translate into transformative practices, unless we critically and collectively reflect on practice and outcomes. Such (meta) reflection requires data and purposefully designed evaluation frameworks-in-use. This idea is not new, but its manifestation in practice was illuminative, and could also be significant for other curriculum and evaluation designers.

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Introduction

TRANSECTS[1,2] is a multi-year, international programme entitled, Transdisciplinary Education Collaboration for Transformations in Sustainability, at the intersection between universities and UNESCO Biosphere Reserves. In sustainability education, there is a quest for

innovative curricula that engage participants in potentially transformative experiences, through which to learn not only how to analyse complex sustainability challenges, but also how to work together towards solutions[3,4]. It is for this reason that TRANSECTS offers Transdisciplinary International Learning Laboratories (TILLs) on three continents.

TRANSECTS situates its TILLs in Biosphere Reserves (regions in Canada; hereafter BRs), these being characterized as "model regions" for sustainability, and an important governance, practice and learning space in complex social-ecological landscapes. The programme invites graduate students to join BR managers in exploring issues experienced in these landscapes, with the aim of developing competencies for sustainability practices.

The TILLs themselves, though interesting as curriculum innovation in sustainability education, are not the main focus of this paper; rather, we share here a reflection on the use of the framework which the authors designed to *evaluate* the TRANSECTS programme[5], including the TILLs[6]. Analysing the use of the evaluation framework to deepen innovative practices is interesting – and a research paper rather than simply an account of practice – because of the manner in which theoretical concepts of sustainability science, transformative higher education and transdisciplinarity[7] are encoded in the framework, and already in the first two years of implementation, informed and deepened by its application.

Context and Literature

The need for pedagogical innovation in higher education

The need for higher education innovation is explored more fully elsewhere in this Special Issue, but one consideration is pertinent here: that universities' responses to sustainability challenges must include pedagogical innovation. It cannot suffice to simply introduce new subjects or new content in existing subjects. Higher education *has* to catalyse and enable *new* ways of thinking, valuing, and doing, which may require un-learning of sedimented patterns of value, thought, and practice, and the development of new habits. Such transformative learning does not simply result from exposure to new information. Learners need opportunities to grapple with existing values and practices, including their own, without becoming defensive or despondent; they need spaces in which to practice working out solutions, and real opportunities to take actions, big or small. Responding to sustainability concerns requires multiple actors to work together, and the skill of enabling collaboration[3]. In complex sustainability contexts, the role-players are many and have diverse and often conflicting interests. Educators have thus been proposing concepts like agency[8]; action

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Suggestion: Make this statement explicite.

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It might be helpful to the reader to give a little bit more details, e.g. length of TILL (for example in 2023), and number of students involved.
In addition: See remark further down for information about number of mentors involved and ratio students/mentor.

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I will be interested to read this, too!
However, I do think that the title might profit from more clarity about the findings of this paper - that a sensitive evaluation-process seems to be fruitful for interdisciplinary curriculum innovation with multiple stakeholders.

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Suggestion: weaken (or open) this statement, e.g. „profit from" instead of need (if you agree with that). Or e.g. add a reference where the necessity is pointed out.

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competence[9]; interpersonal and sustainability competencies[10]; intercultural competencies[10,11]; technical and transformational leadership skills[12], relational and transformational[13] and reflexive competence[14]. Various curriculum and pedagogical innovations that encourage 'active learning'[15] have been proposed, from project work in schools to multi-step social learning processes in industry[16] and the Learning Lab, which was the pedagogical innovation of choice for TRANSECTS. A Learning Lab (also Challenge Lab or Living Lab) is an educational opportunity created for students to engage with a sustainability challenge outside the academy, which is usually multi-facetted, requiring analysis from different disciplinary and non-disciplinary (e.g. Indigenous knowledge) angles. In the Lab the problem is probed through research and stakeholder engagement, and solutions are developed and/or explored, and even tried out to start a further cycle of reflection and development[17]. There are many methods for this[18].

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However, personally I would prefer if you could add a visible difference between a Lab and your format „Learning Lab" and stick to it throughout the text, e.g. maybe use L-Lab or the full two words Learning Lab: In the L-Lab the problem is probed… makes this special format clearer to the reader.

The TRANSECTS programme

The TRANSECTS programme was initiated by collaborating universities in Canada, South Africa and Germany, with the lead partner and main funder in Canada. Implementation activities commenced in 2022. These include a series of Transdisciplinary International Learning Labs (TILLs) – one each year; and annual Programme Institutes, where partners (academics, practitioners and students, from universities, BRs and elsewhere) come together to network, share, reflect, learn and plan.

The team conceptualising TRANSECTS (which includes the authors) also produced an evaluation framework to track, reflect and report on the programme processes, outcomes and impacts over its envisaged six year lifespan. As TRANSECTS is about innovation and transformations in sustainability, we aimed to design a congruent and innovative evaluation framework, to support the transformative intent of the programme, and to optimise ongoing learning.

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Evaluation approaches

When energy and resources are invested in a programme of interventions, courses and resources, evaluation is essential – not just at the end, to satisfy both funders and implementers that this was a worthwhile investment, but also along the way, so as to pick up emerging issues and respond effectively, to improve the programme and its chances to achieve desirable outcomes. Evaluation itself can be costly, and deriving optimum value from it would include *learning*, among programme participants and across multiple evaluations, in the field as a whole[19].

Theories for programme evaluation have undergone shifts over time, that match paradigm debates in broader social science research methodology[20]. Evaluation theory shifts encompass various responses to the observation that educational processes and social change are complex, non-linear, and seldom easy to capture through simple pre-test, post-test measurements[21]. Much has been written about the limitations and negative consequences of imposing an 'experimental vs control group' evaluation design as the 'gold standard', onto non-linear social interventions in complex systems[21-23]. Alternative approaches have been proposed, to evaluate for example programme processes and development[21,22], values and narratives[24], principles[25] and open-ended value creation[26] or identifying the underlying mechanisms that give rise to change[20].

Associated with the latter approach is theory-based evaluation [27]. An early proponent was Weiss[26], who proposed that in order to evaluate a programme of interventions, it is necessary to articulate the programme theory, thus surfacing the designers' theory of how change is likely to come about (theory of change) and their theory of action, explaining why the intervention actions might effect that change. The goal is to evaluate the programme according to this explicit theory, in such a way that the evaluation findings both indicate *whether* the desired change has taken place, and, since there is then also an opportunity to interrogate the programme theory itself, to explain *why* this change happened, or not[30].

All programmatic interventions are typically based on a theory of some kind, and most evaluations proceed from a theory of change. These theories are, however, seldom explicit[21]. For example, the commonly used 'logical framework' embodies a programme theory or logic: If *these* activities are undertaken with *these* inputs, then *these* outcomes will eventually lead to *this* desired impact. *How* X is going to lead to Y, is seldom explained. Thus the recommendations[27 ,22,23] to start an evaluation with the articulation of an explicit theory of change (involving the programme designers and implementers themselves), from which indicators are derived to guide what should be monitored; what data should be collected; and how it should be evaluated. This 'theory' should be open to review, with evaluation creating a feedback loop from which implementers can make not only adjustments to the implementation processes, but also re-think their theory of change. Where necessary, implementers can then revise it, and associated indicators, accordingly. The approach shares the intent of strategic adaptive management[29] and also draws on theories of *deeper*, *higher* or *triple loop* learning (see X and X, this issue).

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This theory-based approach was followed in the conceptualisation of the TRANSECTS programme evaluation.

Evaluation framework and tools for TRANSECTS

TRANSECTS' programme designers produced a standard tabular log-frame about the relationship between programme inputs, outcomes and impacts, but also a non-linear graphic version (Figure 1), to identify three change domains that were of interest: *participants' learning*, but also how *institutions* support transdisciplinarity; and research and engagement *practices* in the BR landscapes; possible relations among these three change domains, and the direction of change (arrow in Figure 1).

This simple version of TRANSECT's proposed 'pathways to change' (another way to refer to a theory of change articulated for evaluation purposes) left out most of the details in the tabular logframe, but hypothesized some relationships. Figure 1 suggests a degree of non-linearity in that the sphere of higher education innovations in the centre, will ripple out in many and perhaps unforeseen ways to encourage participants' learning in the central sphere, which would in turn in many and perhaps unforeseen ways ripple out into changed research and engagement practices in BRs, represented by the broadest sphere on the outside of the graphic. The general direction was presented (and conceptualised) as from the academy, through the learners, to the field.

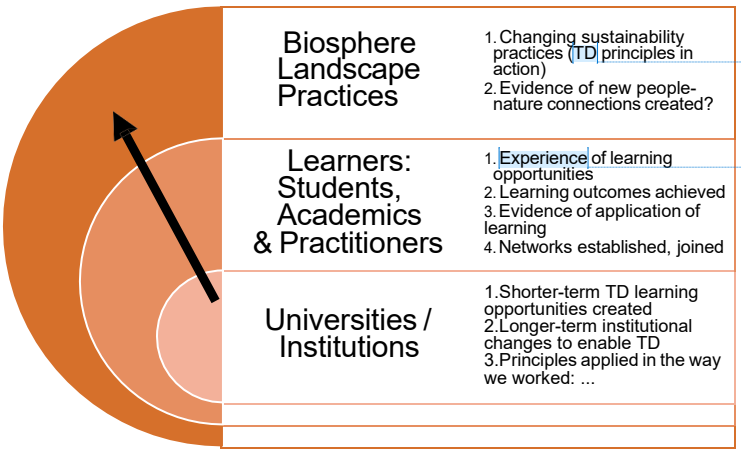

Figure 1: TRANSECTS' Theory of Change

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(Just as an example to point out why a visual representation does provide benefits).

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In the initial stages of programme implementation, somewhat constrained by time and distance (over three continents), the design of the theory of change was neither extensive nor fully inclusive. Nonetheless, there was support for the theory of change. Implementers also agreed that it would be open to change so that from time to time, it should be reviewed and the selected evaluation indicators, instruments and processes adjusted accordingly.

This is standard practice, at least according to theoretical descriptions of theory-based evaluations. An evaluation process based on an explicit, non-linear and evolving theory of change is, however, a departure from the norm in programme evaluation. The MEL team thus undertook to monitor the evaluation framework itself, as it unfolds in-use. TRANSECTS is funded as a capacity building programme, rather than a research programme, but through the theory-based framework, research was built into its evaluation processes, using the theory of change, data collected from evaluating implementation activities, and periodic meta-reflections on emerging findings. This research methodology is described next, as it produced the findings on which this paper is based.

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Methodology on which this study is based

Using the theory of change diagram, planned programme activities were entered in the three domains of change, with associated evaluation questions, and instruments to gather data about those activities where then designed. Broadly, we asked:

- whether activities were executed as planned and according to TRANSECTS' principles[2]
- whether desired learning outcomes, derived from literature in the sustainability sciences and education, were achieved and applied[3,10]; and
- any other outcomes that emerged and seemed relevant to TRANSECTS' transformational intent.

Implementation activities at the start of TRANSECTS focussed on new courses and TILLs in the central 'higher education institution' domain of change, offered to students in the 'participant learning domain'. Two TILLs were offered in Germany, starting with a pilot in 2022. Both TILLs were evaluated, but the 2023 TILL was evaluated more comprehensively,

by both internal and external evaluators. The 2023 TILL and a sub-set of its evaluation findings form the basis of the meta-reflections in this paper.

As the planning of the 2023 TILL rolled out, requiring extensive logistics and communications across three continents, and involving hosts, mentors, and student participants from an even larger number of universities, the Monitoring, Evaluation and Learning (MEL) team designed evaluation instruments and processes for the TILL. These consisted of:

- questionnaires sent to participants prior to, during, and on conclusion of the TILL
- focus group discussions with participants during and after the TILL
- review of student assignments
- focus groups (student feedback and discussions) some months later, during Programme Institutes
- interviews with TILL students
- interviews with TILL mentors on conclusion of the TILL
- interviews with BR practitioners.

An external evaluator conducted some of the focus groups and interviews, and other evaluation activities were undertaken by TRANSECTS MEL team members, including authors of this paper. Interviews and discussions were either in person or online.

Ethical clearance was provided by the [institution anonymised]. Data are stored in a secure Microsoft Teams depository; only TRANSECTS contributors who have completed research ethics training can view the data or engage with participants for evaluation purposes.

In addition to on-site data collection in Germany, some months later students who participated in either of the TILLs shared feedback with mentors and programme staff during a Programme Institute in South Africa. Members of the programme design team who were present then engaged in informal meta-reflections on this feedback and other data that had been collected and analysed. During reflections we applied inter-subjectivity as a means to bring objectivity to our process[31], that is, we challenged each other's interpretations and when found to be sound, built on them. This included a later online engagement with TILL hosts.

In the next section we share the selected findings and meta-reflections that form the core of this paper. Our data sources revealed that while the TILL was a worthwhile learning

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experience for students, and highly rated, in some ways we as a collective fell short of offering the innovative, *transdisciplinary* learning experience we had intended. Our evaluation framework-in-use explained how this might have come about, and these insights can inform wider systemic learning.

Findings

The 2023 TILL took place in mid-winter in a BR in a rural region of Germany. Its focus was on different forest ownership types, with different management objectives (optimum yield vs biodiversity, for example). The students were graduates, most with Masters degrees, from universities across the three continents, selected on the basis of their academic and leadership abilities, and with a variety of disciplinary backgrounds. They stayed in shared accommodation and, for part of the TILL, had to plan and shop for shared meals. Outdoor excursions and meetings were arranged where forest scientists shared their expertise.

Configuring the TILL involved many more role-players than the hosts. Six weeks before the in-situ TILL, students were engaged in a Foundational Course, a series of customised online orientation sessions and seminars, including presentations on transdisciplinarity by academics, and an introduction to Constellation Analysis[32] as a potential transdisciplinary method for analysing complex sustainability challenges and for identifying entry points for strategies and their systemic effects. Three international mentors were appointed, for the first two weeks of the TILL, along with local mentors and instructors.

Despite concerted efforts to involve them, TILL mentors were not all able to attend all the orientation sessions, and the BR managers found it particularly difficult to attend, possibly due to connectivity, language barriers and time zones. This difference between the orientation of the students, and the limited orientation of TILL hosts and mentors, could well have been significant in what unfolded.

Findings: Students' experiences and views

When asked, during and after the TILL, to reflect on their experiences, students noted (among other, some very positive, observations) that:

- The actual problem to research was not clear at the start
- How to contribute from their particular disciplines was also not clear, particularly at the start of the TILL
- Relationship with BR was not clear; were the students meant to be consultants or even free researchers for the BR?

Commented [A27]: Mentioned already above: State duration of TILL 2023 as important additional information to the reader

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- Living together and working with others' differences, was hard for some
- A deeper understanding of transdisciplinary developed
- Students learned much and will highly recommend a TILL to others, but with some changes, e.g. stronger transdisciplinary dimensions and learning mediation.

Findings: Mentors' experiences and views

When interviewed, some weeks after the completion of the TILL, and asked to reflect on their experiences, mentors noted (among other observations) the following:

- The use of transdisciplinary methods during the TILL was not explicit
- Mentors were not always clear on the problem to be researched, or on who should determine the question – students, mentors or BR managers
- The role of the BR managers was not always clear
- The scope of the mentoring was not always clear; to what extent should they steer students, and which aspects of the TILL should they facilitate or support?
- Dealing with interpersonal conflicts was stressful for some mentors who felt unprepared for it
- Mentors would recommend more TILLs (and want to be involved in them) with some changes including more explicit structure and purpose.

Findings: BR practitioners' experiences and views

When interviewed some weeks after the TILL, to reflect on their experiences, BR practitioners noted (among other observations) that:

- The start of the TILL was too unfocused
- Some students had surprisingly little interest in forest ecology
- The BR's roles viz those of the mentors were unclear
- Students were well equipped with technical knowledge to complete set tasks, but more conceptual guidance was needed to bring out conservation and governance aspects
- The quality of the assignments presented by the students to the BR at the end of the TILL, was good.

Another key finding is that when COVID struck during the first week of the TILL, two mentors left the site and proceeded to attempt mentoring online; some students and remaining mentors experienced this as a significant gap in support.

Findings: Programme developers' meta-reflections at the Programme Institute

During the 2023 Programme Institute in South Africa, the authors considered the data collected and analysed thus far, and asked meta-reflection questions which could be summarised as:

- What pattern are we seeing in the data and feedback from TILL participants?

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- What actually happened in the TILLs versus what was intended?
- Why did this happen? What could have given rise to these outcomes?

We concluded that as a collective, we may have conceptualized and approached the TILL more as a Field School, than as a Learning Lab. In sharing with each other what we understood to be the differences between these two curriculum offerings, we found this conclusion to be a sound and powerful explanation for what transpired, that resonated with all of us, and with TILL mentors, when we later engaged them.

In the discussion below we reflect on why this conclusion is warranted, and significant for transdisciplinary and transformative approaches to sustainability education – in relation to TRANSECTS (micro-level) but also to wider theory and system building; a building process that is needed, as argued elsewhere in this Special Issue. We also explain the relationship between the evaluation processes, and our learning.

A summary of the findings from the meta-reflection, is that we learned that transdisciplinary curriculum development for transdisciplinary learning labs across different contexts is:

- more complex than we had anticipated;
- requires more communication between curriculum developers, and between developers and implementers (such as TILL hosts and mentors); and
- requires shared and ongoing clarification of transdisciplinary and pedagogical approaches.

As a collective, we had either misunderstood or under-estimated what transdisciplinary education innovations require, as we elaborate next.

Discussion: Reflection and Elaboration

What is a Field School, and what is a Learning Lab? What are the differences between them, and why did we think that we have in some ways approached the TILL more as one, rather than the intended other?

Drawing on the literature on Learning Labs and Challenge Labs[4,13,32-33] and our experience as higher education practitioners in the Geographical and Sustainability Sciences, Higher Education Scholarship of Teaching and Learning, and Environmental Education, of Field Schools (the term used in Canada) or field trips (the term used in South Africa), we identified a few key differences related to purpose, process and end-points (Figure 3).

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Is there any possibility to reframe it with more positive statements - e.g. does profit from more communication between developers… even more complex than we have anticipated; benefits strongly from shared and ongoing… etc…

A positive formulation might help to avoid the interpretation of your findings as „learning from mistakes", as you state later in the text. These findings are very important learning experiences from the lab - thus they should come with a positive tone.

I do think that it is important to highlight a positive connotation to your findings - to help reframe the interpretation of others that their own experienced „shortcomings/Learning cycles" are just negative failures...

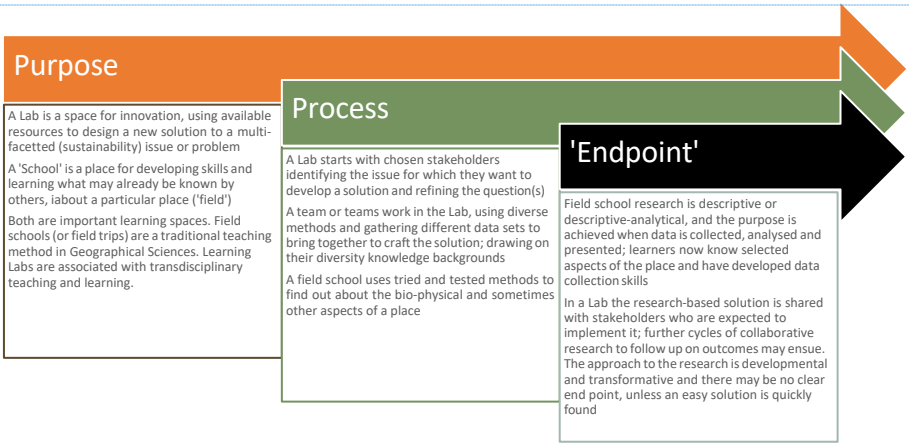

Figure 2: Differences Between Field Schools and Learning Labs (author generated)

The authors realized that the *purpose* of a Learning Lab, to collaboratively work towards a solution for a problem that has also been jointly identified and explored, and share that solution with each other, and possibly a broader range of stakeholders, should have been made clearer to BR hosts, mentors and students. Throughout the TILL, learning should have been mediated with references back to the Foundational Course and the theoretical discussions on transdisciplinarity. The gap left by the early departure of two of four mentors signalled just how important learning support was, not only during the first two weeks, in fact, but throughout – something that was not fully anticipate when the Labs were conceptualized.

Similarly, the contributions of graduates with backgrounds in Politics, Economics, Education, Governance, Forestry, Agricultural Sciences and Ecology, should have been more apparent to all. Students were not attending to simply collect field data as free research assistants. The relevance of inputs from a top Ecologist in relation to the sustainability issue under investigation, should have been clarified, and not assumed, or assumed to be the most important or only input needed.

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Purpose 1: A Lab is a space for innovation, using available resources to design a new solution to a multi-facetted (sustainability) issue or problem

Suggestion. ...to find and design… to support that a Lab often has something to to with exploration, not just designing…

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drawing on their divers instead of diversity knowledge backgrounds (?)

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Learning Labs (and a transdisciplinary process like Constellation Analysis[31]) start with the identification or elaboration of a sustainability issue through stakeholder engagement, because the process of formulating the central problem and associated research question(s) *with* stakeholders (in this case BR practitioners, other forestry owners and neighbours) is paramount and not simply a precursor to the research. Thus, Transdisciplinary Learning Labs require ample time and opportunity for stakeholder engagement.

Lab participants should agree that the key question(s) to research might not be clear at the start; however there should also be an agreed-upon process for concluding what would be the most relevant question to research. This is a fundamental aspect of transdisciplinary work – not just a preliminary step to quickly get out of the way, or to be handed down before the start of the Lab. In the 2023 TILL students, mentors and BR practitioners were either unclear as to what the key research question was, or unclear about how it was to be derived, and by whom.

In some ways we approached the TILL like a Field School where the focus is usually on collecting bio-physical data, for example, by not fully anticipating the requirements for stakeholder engagement. An example is that the majority of BR stakeholders spoke only German, which only a few students could speak, leaving the majority of students unable to directly engage with stakeholders.

We also realised later that students needed to hear explicitly that challenges experienced around living together (deciding between meat or vegetarian meals, for example) were an integral part of the intended learning outcomes. Relational[13] or interpersonal competencies[11] are prerequisites for solving sustainability challenges with others. TRANSECTS proposed to develop intercultural competencies by selecting graduate students from different disciplinary, language, cultural and ethnic backgrounds and nationalities to participate in the TILLs. Resolving the challenges of working across such differences, and using the diversity optimally, are key to successfully addressing complex social-ecological issues[3,7]; however, we did not anticipate just how steep this learning curve would be and that TILL participants would need *ongoing and expert facilitated learning mediation* in this regard. On reflection we realized that our approach to the TILL was predominantly resource-based (asking what resources we have and how best to use them) with less attention to coherent curriculum design.

Mentors were uncertain about whether or how to address the intercultural challenges that emerged. On a field trip, such conflict and taking time to resolve it, is simply a by-product of

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436 the primary focus on co-habiting in a remote area in order to (learn how to) collect separate
437 pieces of bio-physical information. In the case of a Learning Lab, however, 'finding' each
438 other (across disciplinary and cultural boundaries) is a key success factor for working
439 together to address a complex problem. Resolving the problem not only requires participants
440 to communicate and work together, but also to fully appreciate and use each other's diverse
441 contributions. Mentors felt ill-prepared to facilitate conflict resolution; it did not feature in the
442 'job description', and requires skills they either felt they lacked or were not primed to draw on.
443 While mentors and students alike reported that students eventually found peace and
444 even joy in their differences, we collectively missed the opportunity to make the importance of
445 relational competencies[3] explicit, and to provide scaffolding to strengthen learning.
446
447 In a field school, mentors have particular roles: providing instruction about data collection,
448 assisting with technical aspects, perhaps socialising after-hours with students so as to help
449 induct them in the field, and assessment of tasks completed. Roles were less clear in this
450 Lab. What was their role in relation to the setting of the research question, stakeholder
451 engagement, transdisciplinary research skills, and interpersonal conflicts? The evaluation
452 suggests that there was a need for more explicit learning mediation along the way – that the
453 TILL could not be left to unfold without regular feedback to the students, with reference to
454 the intended learning outcomes, and a recommended suite of transdisciplinary engagement
455 methods from which to choose.
456
457 At this point it should be noted that the TILL was by no means a failure. It had many positive
458 features and outcomes. For example, the students' final assignments were of good quality
459 and well received by academics and BR practitioners alike; several students wish to attend
460 the next TILLs as mentors; mentors have offered to participate in future TILLs; and new
461 relationships between BRs and universities were being forged as a result of the shared
462 endeavour. Given such successes it would in fact have been easy for us to overlook the fact
463 that the curriculum offering was *in some ways* simply a more ambitious version of what we
464 would have offered in the past (a field school) rather than the fundamentally different
465 intervention (a transdisciplinary learning lab) we had theorised it to be.
466
467 Why, despite good intentions, did we not entirely achieve the intended curriculum innovation?
468 The fact that we were a multi-disciplinary, multi-lingual team spread across three continents
469 and time zones, may have had much to do with this. Opportunities to develop a
470 shared conceptualization of the TILL, such as online meetings, could not be optimally used due to
471 these constraints. But members of the team who regularly interact with each other and had, on
472 the surface, shared understandings of the nature of the innovation, also approached it quite

Commented [A50]: Thank you for this clear statement - and for the work you put instead into writing up this paper!

Commented [A51]: It might be interesting to the reader on how you would have rated your own experience / capabilites to design such a Learning Lab before you started it - you were no novices at all, and still had such a learning curve!

differently. Disciplinary differences might have had a role in this, and thus it is an instructive example of the situations that transdisciplinary practitioners (including our graduates) find themselves in, in the complex social-ecological landscapes of practice. We also noted that students and mentors *had* been briefed about the ways in which the TILL was to be transdisciplinary … and we can only conclude, retroductively, that transcending years of excellent disciplinary training, was not going to be happen in an instant – unless one applies these ideas in practice, and reflects on them, as we attempt to do here, on an ongoing basis.

In response to the evaluation findings, the TRANSECTS programme designers subsequently took a number of steps to strengthen the planning of future TILLs, including more explicit curriculum planning; assigning and clarifying pedagogical roles for TILL mentors and hosts; careful consideration of the ways in which the proposed TILL focus and research question(s) lend themselves to transdisciplinary and engaged research and innovation; and adjustments to the Foundation Course, which will include evaluation insights. A follow-up Program Institute in Canada dedicated several workshops to flesh out the distinction between a TILL and a field course by determining how to align learning outcomes with activities and assessment for future learning labs.

The findings also effected adjustments to TRANSECTS' theory of change: change does not only take place among learners in the second domain of change; change has to also take place in the central domain *where we as higher education institutions need to change the way in which we conceptualize, design and deliver our curriculum offerings*, based on feedback from the field. This feedback loop and learning would not have been possible, without evaluation, specifically the theory-based evaluation process we followed.

Commented [A52]: I was wondering since figure 1, why you developed in such an interdisciplinary, transformativ setting such a „top-down" learning curve, e.g. that (only) academics/Institutions do have the capability to contribute to solutions…

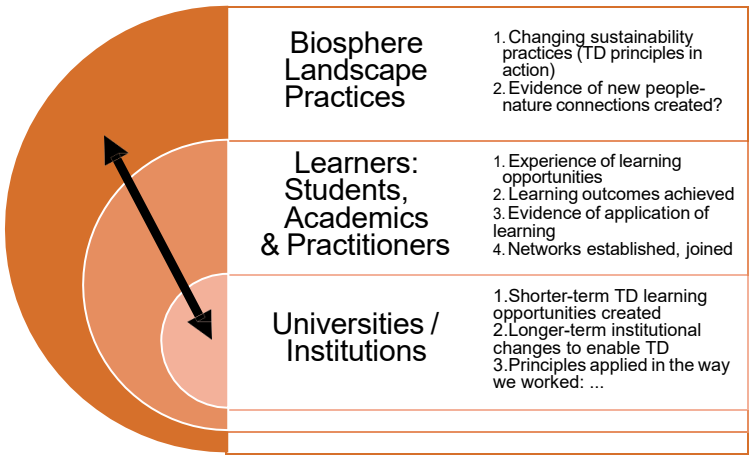

Figure 3: TRANSECTS' slightly revised Theory of Change

As noted earlier, theory-based evaluation[25-26, 28-29] starts with articulating an explicit theory of change from which to derive indicators that guide what data should be collected; and how it should be evaluated.[21,27-28] This theory must be open to review, and evaluative practices should create a feedback loop from which implementers not only refine implementation, but also, where necessary, re-think their theory of change and revise it, and the associated indicators. In this case, we have added evaluation of the process of TILL development to track the extent to which we are designing for transdisciplinarity. Thus the network of learners includes not only graduate students, but also BR practitioners and higher education academics. We had initially indicated this when conceptualizing TRANSECTS[1], but are now clearer on how this learning can happen.

The use of a non-linear theory of change[21,28] influenced the way findings were processed, as it encouraged us to be reflective practitioners that *look across the data* of practitioners, mentors, and graduate students, given that our theory of change presents the relationships between these domains as important but as yet under-theorised. Focus group, interview, and questionnaire data established some common themes: roles were unclear, and cultural practices, previous experiences with transdisciplinarity, and understanding of what a TILL needed to be in order to optimize learning, shaped unarticulated expectations. In troubling the connections between each domain in the theory of change, across the network of

Commented [A53]: See figure 1 for additional comments

Commented [A54]: Comment on the arrow in the figure: It could be interpreted as that here is only exchange between domain one and three, as it is drawn above domain 2 - maybe improve the representation to show that there should be / is feedback between all domains.
In the text you only refer to feedback between inner domain and domain 2.

Commented [A55]: (graphic version) // see comment above: add perhaps the tabular form in an appendix, too!

learners, we realized the extent to which the "learners" included those organizing and leading the TILL. The theory of change afforded deeper thinking than if we had simply counted numbers of participants, or checked whether learning outcomes had been achieved. The educational change process was organic and dynamic, and the theory of change reflected this reality.

The results of evaluation-in-use include deeper iterations of the program theory, notably the distinctions between a more standard field school and what a transdisciplinary and intercultural Lab was intended to do. These insights arose from returning to the expected flow in the theory of change and discussing what evidence indicated about it and why.

The process also resulted in more concrete programme changes, like the redesign of the Foundational Course and the TILL. Ultimately, some of the best evidence of strong evaluation is the capacity to use it in situ[20] to make changes iteratively. A simple, but significant, flow of the key elements for students, practitioners, and mentors made it easier to remember programme goals and engage in deep conversations around what the evidence indicated, without the limitation of a narrower focus on specific outputs or structures of a standard logic model. Working reflexively with a theory of change proved even more significant given the number of people involved in the evaluation, communicating across time zones and cultures, and complex TILL experiences.

Thus we confirm the value of theory-based evaluation and working iteratively with a programme theory. As Oberlack et al.[35] argued:

> ToCs trigger debate among the stakeholders and evaluators of an initiative regarding the hypothesized and observed effects of actions as well as regarding underlying assumptions about how change happens. Therefore, they can strengthen the effectiveness of research, practice, and education in sustainability science.

Our study shows that a theory of change approach to evaluation can catalyze not only a more rigorous evaluation focused on the change process, but it can also frame and catalyse the kinds of relational, and deliberative processes needed to collaboratively make sense of evaluation data and insights, and to make improvements to an on-going program.

Conclusions – The role of evaluation in developing transformative higher education curricula

Commented [A56]: And the adjusted (?) ToC reflected...

Commented [A57]: Intercultural Learning Lab (it was here that I thought that just „Lab" is not precise enough - as I could imagine an intercultural Lab as well as an intercultural Learning Lab.

When one of us shared the outcomes of our evaluative meta-reflection at a conference that invited delegates to explore “bridging theory and practice” the moderator congratulated TRANSECTS on being prepared to share and learn from our “mistake”. The term “mistake” was surprising and served as a reminder that reflective practices – doing and then learning from reflecting on doing - is not a common practice in higher education. The drive for sustainability transformations should surely be characterised by experiments and innovations in which the term “mistake” might not be the best way to describe practice requiring further refinement; there is now more than ever a need to adopt more critically evaluative ways of working. The paper provides one example with an evaluation framework and process that yielded both data and insights; and thus also the evidence that evaluation, if approached as a form of theory-driven and data-informed feedback, can assist sustainability practitioners to deepen their insights and improve their practice.

The paper provides insight into how concepts of transformative sustainability education play out in practice, just how difficult it is to develop a common strategy for transdisciplinary work, and how evaluation can inform more transformative programme design, implementation and learning for *all* participants. As higher education practitioners collaborating across continents and disciplines for systemic transformations in sustainability education and practice, we learned that transformative concepts do not automatically turn into transformative practices, unless we collectively and critically reflect on outcomes. Such (meta) reflection requires data and congruent evaluation frameworks-in-use. While this idea is not new, its manifestation in practice was illuminative, and we have already seen that other curriculum and evaluation designers also find it insightful.

Commented [A58]: Very important observation - and sadly often true!

Commented [A59]: Maybe try to include someting like „exploring“ here - that educators should still, although they can be very experienced in their field, think as explorers or in an exploring way about the educational path/journey they are going to design for/with their students…

It seems approbiate do develop a mindset of exporation, as transformation seems to be by definition a rather unexplored task

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