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E-learning as a mediating tool to support interactive professional learning of teacher educators

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ABSTRACT

This paper examines the development of e-learning mediating tool(s) for an online professional development programme, focusing on sustainability and teacher education, implemented across 11 countries in the southern African region. The paper focuses on how we approached the design and development of an online mediating tool(s) for interactive, situated learning that seeks to support sustainability practices and engagement of teacher educators at a local level while learning together with others across national borders. Using cultural historical activity theory, we elaborate on our understanding of mediation and then focus on the design and the development of the e-learning mediating tool, which we describe as an expansive learning process in our research and practice community. Our main finding is that to establish an interactive learning environment for situated, transformative learning in teacher education settings requires a comprehensive complex process of collaborative learning supported by a range of e-learning mediation tools, that are complemented by on-site engagement and support in communities of practice. We conclude that the successful deployment and use of an e-learning mediating tool depends on interconnected learning systems that is supported by the development of digital literacy skills, continuous online support, and similar communication tools.

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Education for sustainable development; teacher education; e-learning mediating tools; mediation

Introduction

This paper focusses on the design and development of an e-learning mediation tool for a teacher education professional learning programme. The interest of the teacher education professional learning programme, named "Sustainability Starts with Teachers" (www.sustainabilityteachers.org) was to support teacher educators across 11 southern African countries to develop situated ESD "Change Projects" that integrate aspects of Education for Sustainable Development (ESD) into teacher education practice. A situated "Change Project" in the SST programme means a project that develops or transforms curriculum, pedagogy, sustainability practices (e.g. waste management), engages communities in sustainability-oriented practices, or which transforms policy in teacher education institutions. Such "Change Projects" are situated, transformative and are agency-centred and developed and implemented in communities of practice (Mandikonza & Lotz-Sisitka, 2016). Box 1 shares a few examples of the ESD Change Projects developed in the SST programme by teacher educators.

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Box 1. Examples of the ESD change projects developed in the SST programme.

In 2019 the SST programme, developed as a partnership initiative between UNESCO's Regional Office for Southern Africa, and Rhodes University, accepted its first cohort of participants who were able to complete the programme face-to-face. They were given first-hand support for the development of their Change Projects and were also supported in country with face-to-face engagements. In 2020 with the advent of the COVID-19 pandemic, we were confronted with a challenging contradiction: We had to support situated change projects using virtual e-learning approaches. This created the impetus for the action-oriented, expansive learning research we undertook into the design and development of an e-learning tool that could achieve the same results as those obtained through the situated ESD Change Projects that were mediated and supported via face-to-face modalities, which we report on below drawing on theory of mediation, and expansive learning theory that guided our process of e-learning mediation tool development.

Mediation and mediating tools

As reported by Daniels (2015, p. 34), Vygotsky's central contribution to social science is his concept of mediation: "the process through which the social and the individual mutually shape each other". This is a critically important concept in educational research, and it lies at the heart of understanding interactive learning processes and how we might construct these using mediating tools. As introduced above, after one year of implementing our SST programme, we were confronted with a mediation challenge: how to shift from mediating interactive learning using face-to-face support to using e-learning tools to achieve the same outcomes. This forced us to consider mediation theory, and then to apply it to the design and development of an e-learning mediation tool.

Daniels explains that the emphasis on the use of tools, signs and artefacts removes the Vygotskian dialectical mediation process from the "crude domain of social determinism" (Daniels, 2015, p. 35). Wertsch (2007) differentiated between explicit and implicit mediation, and when referring to explicit mediation, Wertsch, drawing on Vygotsky, refers to the importance of psychological tools such as cultural artefacts (in our case this would be the e-learning mediating tool) that could influence behaviour from the outside (Figure 1).

Mediation, or mediation tools, therefore, allows the subject (in our case, the teacher educators) to act upon or in their practice (their object of activity) via encounters with mediation tools or artefacts.

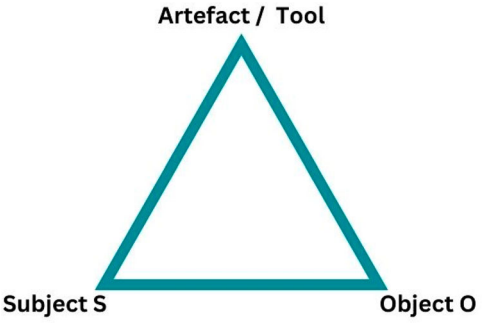

Figure 1. Vygotsky's mediation triangle which shows the relation between the subject, object and the mediation tool or artefact. Source: adapted from Daniels (2015).

Daniels (2015) notes that some theories of mediation focus on the semiotic mediation process, while others, such as the work of Engeström (1993) focusses on how mediation and mediating tools or artefacts influence the activity of subjects. As indicated above, our interest was to support teacher educators to transform their teacher education practices or activities. Some authors also indicate that tools are a sub-category of artefacts. Daniels (2015, p. 36) notes that from Vygotsky's perspective, the use of psychological tools:

> introduces several new functions connected with the use of the given tool and with its control; abolishes and makes unnecessary several natural processes whose work is accomplished by the tool; and alters the course and individual features (the intensity, duration, sequence, etc.) of all the mental processes that enter into the composition of the instrumental act, replacing some functions with others (i.e. it re-creates and reorganises the whole structure of behaviour just as a technical tool recreates the whole structure of labour operations). (Vygotsky, 1981, pp. 139–140)

The above insights were helpful for our reflections on the shift from face-to-face mediation tools to the design of an e-learning mediation tool for the SST programme. We were alert to the fact that the tool itself would change the way in which teacher educators would interact with the learning programme in relation to the design and development of their ESD Change Projects and that it would involve possible changes in forms of engagement and meaning-making. Since Vygotsky's work emphasises the way in which humans use tools to change their activity (Daniels, 2015; Engeström, 1993; Wertsch, 2007), we were also aware that participants in the course would use the e-learning tool differently. This had implications for how we designed the e-learning tool, i.e. it had to allow for diversity of engagement and uptake in relation to the intentions to support the ESD Change Projects. While educational research often focuses on the uptake of mediation processes and how people use and respond to mediation tools in their learning, in this paper, we restrict our discussion to the design of a mediation tool. We observe some aspects of the uptake and response to the mediation tool but restrict our discussion on this to how this affected further design and development of additional mediation tools and processes, leading eventually to an ecology of mediation tools and processes in support of the use of the e-learning mediation tool as it shaped and supported participants engagement with their ESD Change Projects. Explicit mediation, as used in this paper, refers to a process whereby an individual or person (in our case, this would be ourselves as course designers), intentionally introduces as ''stimulus means'' into the ''ongoing stream of activity of another person or persons'' (in this case the teacher educators) who signed up for the SST Course. Implicit mediation would focus more on the sense-making of the participants, which we do not cover in this paper in any depth.

The design of the mediation tool was influenced by the international trend towards supporting educators to reinvent education to help address real-life challenges that are arising around the need to support planetary sustainability and human well-being. For example, the objective of the new social contract for education articulated in the UNESCO ''Futures of Education'' report is to unite

around collective endeavours and provide the knowledge and innovation needed to shape sustainable and peaceful futures for all, anchored in social, economic, and environmental justice and an understanding of education as a common good (UNESCO, 2021), hence also our interest in supporting ESD Change Projects, in which teacher education communities of practice develop situationally defined transformative education projects. The capacity-building programme is built on ESD and learning processes that involve the acquisition of new knowledge (critical thinking, systems thinking), ethics (e.g. care and empathy), action competence (abilities to act), and agency (evidence of action), and a commitment to transformative co-engaged, active learning pedagogies. It aims to encourage teachers and TVET educators to put transformative education and learning towards sustainable development at the centre of their educational work. Thus, the SST programme seeks to support teacher educators to prepare future teachers for teaching sustainability across the curriculum, using whole institution and action-oriented approaches that involve the lecturers, students, communities and other partners in ESD practices.

In response to the COVID-19 pandemic, and as we had to shift to the design of an e-learning mediation tool, we were challenged to design an e-learning platform that had to replace course books, notes, assignments, on-course face-to-face activities, and lectures and supplement the in-country institutional support for change project development in localised communities of practice. The development of the e-learning platform aimed to support sustainable development and transformative learning by creating a new space where active learning and knowledge sharing were possible during Covid.

Designing the e-learning mediation tool: an expansive learning process

Methodology and approach

Restricting the course to an online version required a significant investment of time, resources and a multi-skilled team of people to offer and run the course online. The paper focuses on the iterative process of constructing and using the e-learning mediating tool and its ecosystem to support the in-country, institution-based Communities of Practice and transformative learning processes via the ESD Change Projects. This article is focused on the following research questions:

- How can an e-learning tool be designed as an explicit mediating tool to facilitate expansive learning and transformations toward sustainability in teacher education settings?
- What conditions need to be in place for the development and monitoring of the e-learning tool to ensure that it can mediate transformative learning and agency?

This paper elaborates on the complex e-learning ecosystem that evolved from the design and development of the e-learning mediation tool (the SST course platform) and draws on cultural-historical activity theory (CHAT) to elaborate the action-oriented expansive learning methodology that we used co-create and formatively use the e-learning mediating tool. In designing the e-learning mediating tool, we drew on the second generation of cultural historical activity theory, building on the basic principles of mediation outlined above in Vygotsky's work. Engeström (1987) further developed the of post-Vygotskian work of Leon'tev, who emphasised the importance of object-oriented activity. His work highlighted the importance of mediation tools and artefacts in **activity systems** where subjects interact with mediation tools, rules, and other members of their communities and via divisions of labour to advance their object of activity. We chose this focus because of our interest in supporting changes in activity as mentioned above. This required that we not only give attention to the e-learning mediation tool, but also to the broader e-learning activity system, including the rules of the e-learning activity system (e.g. accreditation rules and rules set by the project partnership agreement with UNESCO and Sida who were partners in the project), its community (made up of Rhodes University and UNESCO staff, country-based reference group members, and international partners), it's divisions of

labour (e.g. UNESCO supported the in-country Change Projects while Rhodes University staff were responsible for delivering the ESD capacity building course). The design of the e-learning mediation tool was influenced by Engeström (1999)'s work which suggested that activity theory is a valuable tool for analysing systems and may be simplified with the help of five principles, namely: seeing the object-oriented activity system as the prime unit of analysis (in this case, our object-oriented activity system of ESD course design and delivery); keeping in mind the multi-voicedness and historicity of the system (what we had done that worked before that we did not want to lose, our partnership structure, and the purpose of ESD capacity building); seeing contradictions as sources of change and development (the dilemma of having to shift to online mediation at short notice noted above), and lastly; recognising the possibility of expansive transformations (the present paper captures these). Cultural historical activity theory further elaborates that artefacts or tools are products of cultural and contextual requirements (Kaptelinin & Nardi, 2006), it emphasises social interaction within an activity context. We worked through an expansive learning process to design the e-learning tool (see Figure 1), involving questioning and analysis of the problem and modelling the new solution (e-learning mediating tool). This was then followed by a using it and evaluating it (Phase two). Expansive learning is a process wherein learning and transformation are achieved through specific learning actions that form an expansive cycle (Engeström, 2016).

Data for Phase one and Phase two were obtained from two substantive monitoring reports developed in year one and year two of the programme (REFS), and from monitoring data that captured data on the use of the platform, as well as the value created for participants. In constructing this paper, we drew on this body of data to explain how we went about designing an explicit mediation tool for interactive learning (Figure 2). Data were produced through collaborative self-ethnography of the construction of the e-learning ecosystem, followed by system analysis of the construction processes through team discussions. Construction, technical and monitoring data was derived from the e-learning management system (back-end data) and the data-free version of the online learning platform. This data allowed better insight to get continuity in the mediation tool. All the data were captured in the course reports. These reports included the Sustainability Starts with Teachers Course Report (Lotz-Sisitka, 2021), the Sustainability starts with teachers Communication report (Lotz-Sisitka, van Staden, de Sousa &,Chetty & Mponwana, 2022a), and the SST Course Formative Evaluation and Annual Progress Report for 2021 (Lotz-Sisitka et al., 2022a). An additional tool for evaluating the course process was used at the end of the course in the form of a questionnaire to gain insight into which aspects of the course were valuable for course participants and their institutions.

Results – phase one: establishing and constructing the e-learning mediating tool and ecosystem

Questioning phase

As indicated above, the COVID-19 Pandemic required us to shift rapidly to an accessible online modality in 2020. In this phase, we focussed on the question of how to achieve the initial objectives of building on ESD learning processes that involve acquiring new knowledge, ethics, action competence, agency and our commitment to transformative co-engaged, active learning pedagogies so that participants could still complete ESD Change Projects in their context. This required us to consolidate the principles of the pedagogical approach. It became clear that what we thought was needed for the process of transitioning to an e-learning platform was not as straightforward as expected and that we needed to give attention to pedagogical principles, as well as technology affordances, while also considering how new technologies mediate learning. In this phase, we learned that designing an explicit mediating tool required us to question what platform to use, how to structure the online platform and how to best address the needs of the participants to ensure that we would obtain the same success as our face-to-face course.

Figure 2. The expansive learning process followed during the construction and implementation of the e-learning mediating tool (Engeström, 1999).

Analysis phase

We undertook further analysis to identify what is required to construct the e-learning mediating tool and its ecosystem. From this, we learned that many components of the development and management of an e-learning mediating tool need to be attended to. Figure 3 illustrates all the anticipated components and actors we identified to support the development and implementation of an e-learning mediating tool. The roles included pedagogic development, course design, administration, e-learning coordination, custom building and maintenance of the website, development and management of the Learner Management System (LMS) and e-learning platform, tutoring and webinar hosting and providing digital literacy support sessions.

Discussion with the course and country coordinators, course developers, web designers, and graphic designers in this phase was essential to fully understand the complex range of tasks and division of labour in the construction of the e-learning mediating tool. We also had to consider participants' data requirements, device preferences, digital literacy capacity, computer literacy levels and time availability in this phase of the design of the e-learning mediation tool. Some of the key findings of this stage include:

- Testing the online learning platform with the group that will lead the course, including the coordinators and managers is a good way for everyone to understand how the online learning platform works and the proposed systems of contact and assessment.
- Digital skills development for the e-learning team is essential.
- The only way course and country coordinators can fully support participants and provide input is if they have completed the whole course beforehand themselves.
- Learning innovation will only occur if participants are supported continuously on the online learning platform.
- The course design needs to be flexible to allow one's teaching and learning strategies to be adaptable to address every individual participant's needs.

Modelling of new solutions

In May 2020, we designed the first prototype of the e-learning mediating tool. This consisted of the www.sustainabilityteachers.org programme website, which provided a resource-based

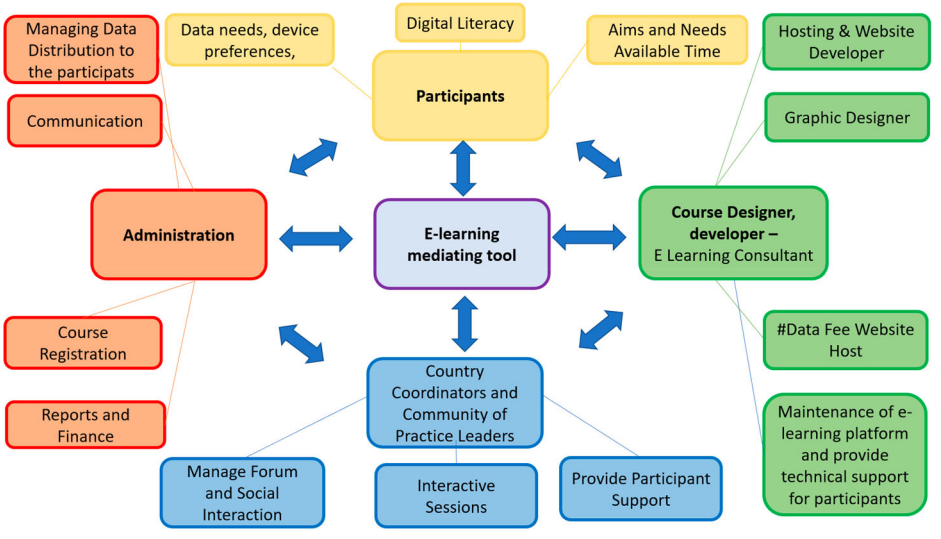

Figure 3. An outline of our anticipated e-learning mediating tool and its ecosystem.

platform where the online course could be hosted. This provided a seamless platform which included the SST programme's communications and records of previous course Change Projects, which could expose the different cohorts of course participants to each other's work, and give them access to the entire resource base of the programme, including videos, resources, course materials, and the e-learning library, as well as programme news and the alumni forum.

Additionally, the online course was developed on an associated platform and website that was linked to the main SST website (course.sustainabilityteachers.org). A LearnDash WordPress LMS was utilised to ensure an active learning experience and good communication between participants and course coordinators. Different learning practices, various course material formats such as text, PowerPoints, Voice Notes, YouTube video links, additional documentation, Forum interaction and references that users could click on to further their research were used to make the learning experience more interactive and engaging. Some of the key considerations and insights gained in this phase were:

- It is important to include various different resource materials and types of resources to enhance learning.
- Setting up structure for the learning, assessment and evaluation processes are essential to ensure that there is communication between the course facilitators and the participants.

Examining the new model

The modelling of the e-learning mediating tool and its ecosystem allowed us to understand what it takes to move courses online clearly; and what it takes to do this in a professional, helpful manner that embraces a responsive, learning-centred and reflexive approach. Once we were confident the course content and structure seemed in order, we scheduled a "trial run" with the allocated Reference Group Members (RGMs) from three participating countries, namely Lesotho, South Africa and Botswana, UNESCO ROSA coordinating staff, and other members of the Environmental Learning Research Centre (ELRC) at Rhodes University.

During the examination of the new model, it became clear that the construction and use of the e-learning mediating tool and its ecosystem involved three critical components, all of which are essential to the success of the intended interactive learning process. These include:

(1) e-learning course design, technical and pedagogical support,
(2) platform and online hosting support, and
(3) course content facilitation support.

With regards to (1) above, the key lessons learned were that one must be in the position that you can adjust the e-learning platform when necessary and understand that the platform as a mediating tool will be every changing and address the needs of the course participants. Providing support to the participants and making adjustment to the course to address their needs are an essential part of ensuring that co-engaged active learning takes place mediated by the learning platform.

With regards to (2) above, during the examination of the e-learning ecosystem, it became clear that participants would struggle to access the course as they have limited access to Wi-Fi and mobile data is expensive. The problem of data expense for participants, given the situation with internet access, was resolved by developing a data-reverse version of the online course to ensure that the course was accessible to everyone. When participants within South African access the website via their mobile phones using the data-free version link, they are not charged for any data usage. The data costs are then transferred to the website owner. On such a data-reverse website, participants can access all the pages, download any documents, listen to any podcast and watch any video on the website in the same ways that are available for all other participants without incurring any data costs themselves.

With regards to (3) above, the key lessons learned were that course participants needs to be supported every step of the way and the course facilitator must also be technical savvy enough to assist with small problems such as ''login'' issues. Working online is difficult for most people and navigating a new course can even be stressful. Therefore, it is essential to comfort the participants and let them know that what they are experiencing is normal. Once the participants are confident and know that they have technical support then they continue with the course much more comfortable. There should also be someone that can answer the quick questions such as: ''I can't find the assignment on my page'' or ''Is my assignment in the correct format'' or '' I cannot upload my assignment''. Supporting participants with these small issues, that can seem extremely big to them, ensures that they enjoy the course and just give their best.

Phase 2: using, monitoring, and improving the e-learning mediating tool and its affordances

Implementing the new model

In September 2020, the online course opened for registration. The course was launched with pre-course digital training sessions. The sessions provided training for the participants on how to log in, the course structure, navigate the online platform, upload assignments, engage in Forum discussions, find resources and materials, and a progress tracker. A total of 165 lecturers of TVET Educational institutes from Lesotho, South Africa and Zambia registered for the online course.

Following the preparatory work required to design and set up the online course, we also needed to do work to draw attention to and complement the online course contents. Given the COVID-19 situation, we decided to run three-week webinar sessions followed by a second set of two-week sessions. This was necessary as one of the realities of using webinar conferencing support services to boost online learning programmes is that video conferencing platforms such as Zoom and Microsoft Teams require constant packets of data being sent and downloaded in real time. We transferred 100MB of data to each participant for two weeks. The UNESCO team and group leaders closely monitored the participants' progress.

Another essential feature of the 2020 SST programme was the emphasis on sharing Change Projects across the 2019 and 2020 courses. We invited some participants from the 2019 course to present their Change Projects in a formal webinar. We have repeatedly referred participants to the Change Projects from past course participants hosted on the website. The WhatsApp groups were created between the UNESCO ROSA offices, and the coordinators can discuss shared matters of concern related to the course organisation and facilitation processes. Without this mechanism, it would be challenging to maintain good communication and stick to the course development timeline. The development of the ecosystem components to support the e-learning mediating tool was essential for the success of the implementation of the programme and the development of the institutional change projects.

Reflecting phase

Overall, we have received positive feedback on the design of the course and its easy-to-follow structure and the interactive features that we included to support participants under all the problematic conditions of connectivity issues and load shedding. A key lesson learned overall is that there is a great need to develop and implement e-learning **ecosystems** as mediating tools, and that design of one tool only (e.g. the course LMS) is an inadequate mediating tool on its own. The course was initially just an e-learning platform. We learned this key lesson as we discovered the need for additional components such as webinars, WhatsApp groups, interactive forum discussions on the platform, whole-institutional change projects and knowledge dissemination between participants which were needed to enable the kind of interactive learning we were aiming for. We realised that there was need to create an **e-learning ecosystem** to support the e-learning mediating tool, and that explicit mediation required more than just one tool or form of tool. The interaction with the course participants during the implementation phase made it clear that the mediating tool reaches more remote participants and makes active learning possible during difficult circumstances. This realisation led to further reflection and data gathering on increasing the effectiveness of such an e-learning ecosystem.

There was continuous formative monitoring of activity on participants' progress and activity on the online platform. The online course activity was continuously monitored with the support of Google analytics and LearnDash LMS. The upload of assignments, forum discussions and forms completed by the participants were also closely monitored. The data from the backend of the course report on the participants included their contact details and the progress they were making through the online course. This helped us to flag the participants that are not actively participating in the online course so that we could contact them and see how we can support them more. It also provided us with data on who is struggling to login because sometimes participants would not contact us when they cannot login; they usually don't try again. So, by contacting these participants and assisting them in accessing the e-learning platform successfully, we ensure active participation. allows RGMs / tutors to see who may need additional support and also when it might be helpful to encourage course participants to continue completing aspects of the online course. It also shows the last course activity a participant completed, showing what module the course participant is working on and when they last visited the site.

With a Value Creation Framework (Wenger et al., 2011), an evaluation of formative monitoring of social learning processes and outcomes was possible. Value creation data were gathered from the course participants completing an online questionnaire that is part of the online course programme and interviews (Figure 4). The data from the Value Creation questionnaires from course participants shows that the different dimensions of the mediation process that were constructed via the e-learning mediation ecosystem were useful to participants. Box 2 shows some of the evaluation data.

Figure 4. Value creation framework adapted from Wenger et al. (2011).

Box 2. Example of our value creation data from one of the participating institutions.

Mongu College of Education Mushinga Kapelwa Mooto Mwangala Connie Kalumiana	**Outcome:** Integrated Education for Sustainable Development (ESD) into Early Childhood Education (ECE) via urban gardening **Value created for the participant and institution:** **Immediate value:** Integration of urban gardening within the lesson and daily program (Learning and child play) by the ECE student teachers; General management of vegetables growing in sacks by students and later by ECE learners; and Identification and exploring of ESD matters in the Teacher Education syllabi and ECE school syllabi. **Potential Value:** Personal assets (human capital): The seemingly difficult Integrated teaching approach at ECE is achieved. **Potential Value:** Relationships and connections (social capital): Education authorities and stakeholders realise and appreciate that gardening is a component within child play. **Potential Value:** Transformed ability to learn (learning capital): Replication of the gardening by the parents at home is milestone for attainment of SDGs. **Reframing Value:** Application of Indigenous Knowledge Systems to learning situation; Indigenous games and activities within the learning program; and That Gardening is an integral part of schooling/ education is accepted from inception.

For most of the respondents above, the process of working on change projects and the exposure to the online course and webinar series have proven to be helpful. The change project is vital to building a solid regional Community of Practice and building confidence in the change agency process. The programme supported the development of a regional community of practice and international and smaller communities of practice to create and extend the networked approaches of the programme – across cohorts and with other participants from other year groups. The cluster meetings are also seen to be valuable. The examples of previous change projects, the encouragement to develop relevant programmes and projects for local contexts, and to enrich their knowledge and engagement with policy also proved to be helpful to the teacher educators engaged in the SST programme.

Consolidating new practices

To address the challenges experienced in the execution of the first iteration of the online course, and based on the key findings of our formative monitoring evaluation work, we put in place several adjustments to the online course for 2021 (Lotz-Sisitka et al., 2022a). These include:

(1) Additional support for online learning and dedicated online learning coordination and interaction support
(2) Parallel WhatsApp system for rapid communication
(3) Course Completion Challenge
(4) On-site visits to institutions to support Change Project progress

After that, we were ready for the next group of participants. The number of registered participants doubled for the 2021 online course to 322 registrations from Malawi, Eswatini and Tanzania.

The e-learning mediating tool provided enrichment opportunities to encourage participants, build the regional network, and help share experience across countries and across the programme cohorts, as well as into the ESD Alumni network structure, which forms a strong foundation of the SST programme. In this phase, we implemented yet another mediation process in the e-learning mediating tool "ecology" in the form of a "Course Completion Challenge", where participants join sessions to complete the course together and share progress on their change projects. The course completion challenge consists of a WhatsApp group and weekly zoom meetings where the participants go through the course together, share their change projects and ask for technical support. It is well known that registration for an online course does not easily equate to achieving it. International figures benchmark online course completion rates at 13%. Using this global average as a benchmark, we could thus expect the completion of at least 20 participants for the 2020 cohort and 42 participants in the 2021 cohort (Lotz-Sisitka et al., 2022a). This led to more completions on our online course. To date, we have achieved a 47% completion rate which is higher than the international average and we still have 323 participants aiming to graduate in March 2023. For a region that struggles with internet connectivity, we found this to be an important finding and lesson i.e. that one needs to provide additional mediation opportunities in addition to the e-learning ecology of mediation tools.

Discussion: key lessons learned on design and development of an e-learning mediation tool

Our findings are essential to support the future design and development of e-learning mediating tools to support teacher educators. There are so many pitfalls, and our study outlines through our lessons learnt was is important to take into consideration when designing, developing and implementing a successful co-engage online course to support the ground Change Projects. Through the process of designing and developing the E-Learning platform, we have learned a great deal about course design and online co-engagement learning. We learnt that developing a course design and processes to ensure that participants not only complete the online course but also engage with their institutions and communities to implement their Change Project needs careful planning. There are various components and roles to ensure the success of the online course (Figure 3). However, each person involved in the development and implementation of the course needs to complete the course themselves before it is accessed by any participants. This ensure that everyone understands what is expected from the participants and thus can support the participants better. Pre-digital literacy sessions with prospective course participants are essential to understand what the needs would be of the participants and the level of digital support they will require. Even though we made videos on "How to login" and "How to Navigate the online course". Pre-course training sessions were very useful to get everyone to register at the same time and access the course. Afterward we provided weekly support session where participants can join via zoom and explain what their technical or course content issues are. Therefore, it is essential that the person that provides the technical support should also be a course coordinator. In our experience, that is the recipe for success.

During the e-learning platform development, the team gain additional ICT and e-learning pedagogical skills. The Group Leaders, RGMs and course coordinators also received training on managing and utilising the LearnDash LMS system. During phase 1, the team underwent digital capacity-building training. Knowledge of e-learning pedagogy was also obtained. The objective was to encourage participants to utilise the e-learning mediating tool to support their change project development. We realised that this requires a high level and high-quality technical assistance to ensure success.

Knowledge and understanding of the pedagogy and purpose of the course are essential for hosting and running an online course of this nature, especially in circumstances where the technology is not normalised in everyday practice as yet, amongst regional group leaders, course coordinators or participants. The type of assistance provided on an ongoing basis includes support with recalling passwords, accessing the site, fixing glitches with the Pomegranate team as they emerge, and support to group leaders on how to comment on an assignment.

Developing the e-learning mediating tool and its ecosystem requires a significant investment of time and resources. It requires and continues to need a multi-skilled team to offer and run a course online. The ''myth'' that online learning is more accessible fails to consider the background investment, time, and intensive support required. However, the major work was to translate these materials and the course curriculum framework and its pedagogical approach into an online course that would be accessible to course participants in the SADC Region under conditions where electricity is at times erratic (i.e. many countries experience load shedding), and where internet services are also unstable and often poor, and also expensive. This was more so the case during the initial periods of the COVID-19 Pandemic when most of the course participants were working from home and were not at their places of work, where more stable internet services may be available to them.

This research confirms that digital education and ICT competence are essential components of the implementation of ESD in terms of strategic innovation, pedagogy renewal, teacher training, inclusive institutional development and partnership with other regional and international actors of sustainable development. From the data from this study, it is clear that the course is enriching participants' knowledge of ESD and how to apply its principles and approaches in their contexts (Lotz-Sisitka, 2021; Lotz-Sisitka et al., 2022a). The findings highlight that in order to utilise e-learning as a mediating tool capable of facilitating expansive learning and transformation towards sustainability, certain conditions need to be in place, which is necessary for both the development and monitoring phases. These include adequate time, an understanding of the e-learning pedagogical processes and learning platform functionalities (requiring upskilling of the digital literacy of the development team and other actors). Workable, data-efficient or data-free, smartphone-friendly training and communication platforms are needed. We found that the successful deployment and use of the e-learning mediating tool (the online course platform) were dependent on interconnected learning systems that supported the development of digital literacy skills and continuous online support, as well as similar communication tools such as WhatsApp and community of practice support that helped situated change projects that contextualised the course in contexts of practice. Lastly, one must remember that these ESD courses mean a great deal to the participants. The courses are not only a capacity-building opportunity but an opportunity to share their knowledge-built networks and better their communities through their change projects. More importantly, it's an opportunity to excel professionally. Our research shows that the SST programme meant a great deal to the participants who completed the course and are continuing with their change projects and supporting other colleagues who still need to complete the course. It is an essential part of the ESD programme not to leave anyone behind. Therefore, one must provide enough time for participants to complete or reregister for the course. The course challenges and continuous international between countries and local support in difficult circumstances is essential to ensure successful long-term sustainable transformation and innovation. Therefore, we all need to give careful support to the Change Projects and the collective support and synthesis work that emerges across the contexts and cases.

Conclusion

The case study indicates that by using information and communication technology (ICT) tools, ESD capacity-building programmes within southern African countries can be successfully implemented. It is essential to focus on e-learning course design and technical support, pedagogical support,

technical platform and online hosting support and course content facilitation support when constructing and utilising an ESD-aligned e-learning mediating tool and ecosystem. What is also evident from the data gathered during this study is that the course also supports "changes in mindset" and empowers participants to take up agency for change in their institutions and the company of others.

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Data availability statement

The data reports associated with the paper and referenced in the paper included in Lotz-Sisitka (2021), Lotz-Sisitka et al. (2022b).

Data deposition

Geolocation information

Study was conducted in Southern Africa in Lesotho, South Africa, Zambia, Tanzania, Malawi and Eswatini.

Supplemental online material

Website Link: https://sustainabilityteachers.org/change-projects/.
Online Course Link: https://course.sustainabilityteachers.org/.

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