Virtual Learning Networks for Sustainable Co-engaged Knowledge Dissemination and Activity Transformation

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Abstract

Learning Networks in environment and sustainability education are increasingly used as a social learning mechanism for sharing knowledge and building capacity outside of, or to complement and extend formal training processes (Lotz-Sisitka et al., 2022). During the COVID-19 pandemic, many in-person Learning Networks transformed into Virtual Learning Networks (VLN). Subsequently, some of these Learning Networks thrive while others die quietly.

This article investigates the elements, functioning and mechanisms of four VLNs that have been supported through WhatsApp, co-ordinated by the Environmental Learning Research Centre at Rhodes University. All have a focus on environment and sustainability knowledge sharing and operate in a virtual space. This study, constituted as a reflective review and analysis, seeks to understand the factors contributing to the sustainability of such networks and to identify actions that might improve the chances for future success. Two of the networks are regional / national networks; the other two are provincial networks. The study also considers some of the challenges in sustaining the networks.

We drew on second generation Cultural Historical Activity Theory (CHAT) and, using activity system mapping, we developed a contextual profile for each Learning Network. Data was obtained using a Net-Map Social network mapping tool and WhatsApp Network Group Chat analysis. We augmented our analysis with interviews with 25 members of these Learning Networks to identify, from their perspectives, the key factors that influence the sustainability of networks, how members see their roles and how members feel that they benefit from the networks. The study also draws on earlier in-depth research conducted into two of the learning networks (Lotz-Sisitka et al., 2022; Meterlekamp et al., 2021). It considers whether transformative learning and knowledge dissemination occur, and at what levels, and seeks to develop understandings, approaches and tools necessary to increase the chances of future success of the VLNs. We conclude that VLNs, at their most dynamic, can be effectively utilised as knowledge-sharing bases and can benefit their members. We also conclude that such networks require continuously engaged and stimulated interactions within an established community of practice to be sustained.

Keywords: *Virtual Learning Networks, agricultural education, knowledge dissemination, Cultural Historical Activity Theory*

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Introduction

Learning Networks in environment and sustainability education are proving to be a valuable means for sharing knowledge and building capacity to complement and extend formal training processes (Lotz-Sisitka et al., 2022; Meterlekamp et al., 2021). Learning Networks consist of people and organisations that come together culturally for mutual learning (Meterlekamp et al., 2021). In a Learning Network, people work together, collaboratively sharing ideas and information to learn about something that affects them all. It is not an easy process to establish a Learning Network. It has been noted that learning institutes can play an important role in supporting the establishment and formation of Learning Networks (Lotz-Sisitka et al., 2022). The learning networks under study here are all course-activated Learning Networks established around specific knowledge pathways (Lotz-Sisitka et al., 2022) in the Environmental Learning Research Centre (ELRC) at Rhodes University, which is a learning institution. Reflecting on one of the more established Virtual Learning Networks in the ELRC, known as the Imvotho Bubomi Learning Network which has been active since 2014 (IBLN), Meterlekamp et al. (2021) developed guidelines for establishing and supporting an effective Learning Network and noted ten important considerations when starting a Learning Network. Figure 1 illustrates these considerations.

These points in Figure 1 emphasise that establishing a Learning Network begins a long-term process as the network

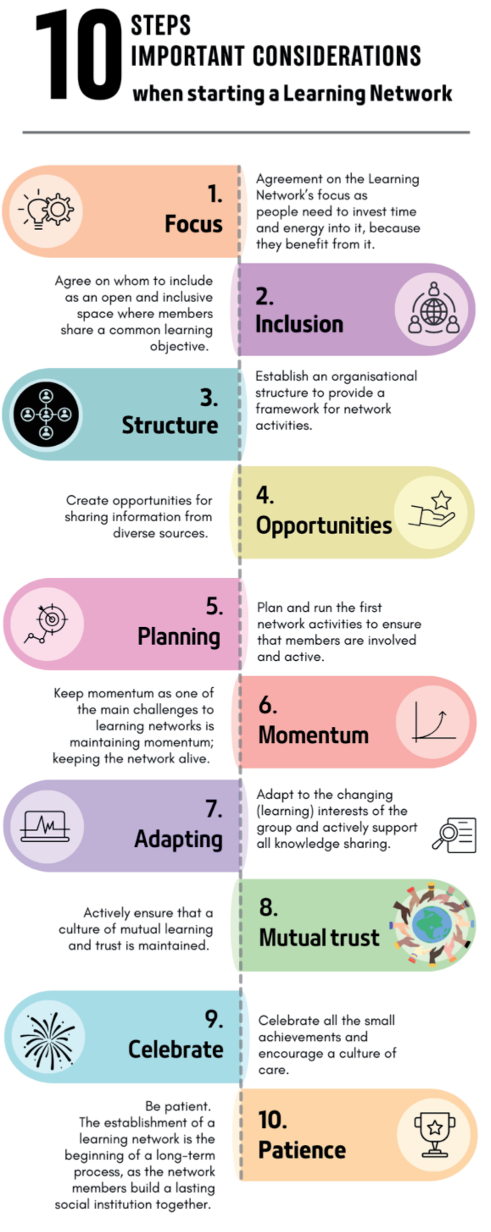

Figure 1: *Ten important considerations when starting a learning network (Meterlekamp et al., 2021)*

members seek to build a lasting social institution together. Figure 2 illustrates how the development of a network can be broken down into four phases (Metelerkamp & Monk, 2023).

Phases of Learning Network development process

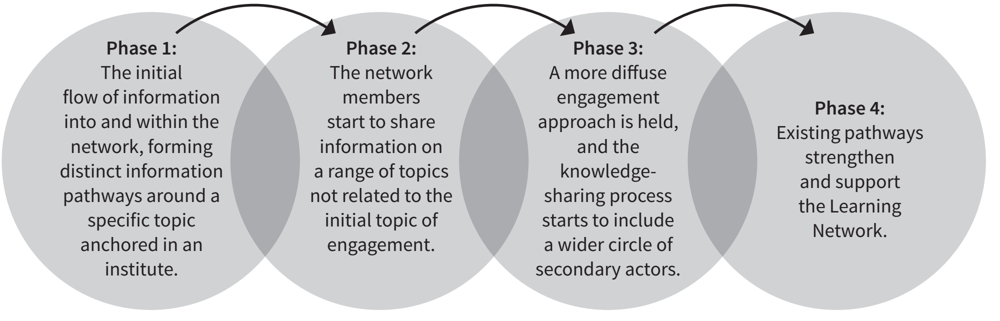

Figure 2: *An outline of the phases of the Learning Network development process (Source: Meterlekamp & Monk, 2023, p. 5)*

The fundamental purpose of any Learning Network is to bring members together to share practice, ideas and experience. This applies equally to networks based on face-to-face interactions and those operating through virtual platforms (Meterlekamp & Monk, 2023). Some, of course, involve both approaches. The Learning Networks in focus in this study evolved from face-to-face to almost entirely virtual networks supported by WhatsApp groups following the onset of the COVID-19 pandemic. This shift to a virtual platform was not without its challenges. Over time, it has become apparent that some Virtual Learning Networks (VLNs) thrive while others die quietly.

A key consideration to ensure that VLNs are sustainable and functional is understanding of both the opportunities presented by such networks and the challenges they face. This research aimed to understand the functioning, elements and mechanisms of VLNs to develop understandings, approaches and tools that can potentially increase the chances of future success for the learning networks. We focused on finding answers to the following key research questions:

- What are the key factors or contradictions that inhibit a VLN and prevent it from being alive and active?
- How do these contradictions affect the VLN's activity and sustainability?
- What mechanisms and processes are involved in sustainably establishing a mutually supportive VLN?
- Can a VLN be effectively utilised as a knowledge-sharing base?
- What are the benefits of these VLNs for the network members?

As the VLNs under study are all course activated learning networks, connections between the members of the networks involved in this research were established through their co-engagement with the various training courses and, therefore, strengthened by their shared interest in the topics being studied. These were originally face-to-face training interactions, so network members had got to know each other in person (cf. Lotz-Sisitka et al., 2021). Later, iterations of the training were virtual, and the members had no opportunity for further direct contact with each other. This has probably been one of the main challenges to the sustainability of the VLNs.

On the other hand, one of the greatest strengths of the virtual networks has been their ability to bring together actors from different sectors. In the case of the Imvotho Bubomi Learning Network (IBLN), farmers, homestead gardeners, extension services, NPOs, academics and students, gathered around their shared interest in Rainwater Harvesting and Conversation (RWH&C) for food production. As the network evolved, members started to contribute ideas and information about other issues affecting their agricultural practices, a process through which the network expanded into a more generalist food security platform (Lotz-Sisitka et al., 2022). This provides some insight into the potential for the use of VLNs as sharing platforms across the environmental and agricultural education and training sectors.

Theoretical framework

This research draws on the unit of analysis in second generation Cultural Historical Activity Theory (CHAT), which offers the activity system as a focus for analysis of the various Learning Networks (Engeström, 1999). We decided upon this approach as it allows for understanding course activated learning networks as cultural historical activity systems with subjects that have a potentially shared object, that are multi-voiced, and that may experience contradictions as sources of change and development. We also drew on this framework for analysis, as it allows for possibilities for transformation through expansive learning as a boundary crossing and network building process (Engeström, 1999).

According to Engeström, expansive learning is a dynamic process that extends beyond individual cognition to include collective activity within activity systems that share an object. Through network building, members involved in activity systems can create new connections and collaborations, fostering innovation and the emergence of new knowledge and practices (Engeström, 1999). The notion of contradiction in CHAT assists in identifying the tensions and conflicts of motive that may emerge in and affect the VLN activity systems. Engeström's four contradictions are also referred to as structural tensions that may be considered sources of change or development (Engeström, 1987). The primary contradiction arises within the elements of the activity system (Subject, Object, Tools, Community, Rules and Division of Labour – see Figure 3). Secondary contradictions occur between the elements of an activity system. Tertiary contradictions arise when a culturally more advanced activity system interacts with the central activity of interest, introducing a more advanced object, fundamentally changing the purpose. Quaternary contradictions can emerge between the central and outside activity systems. In the context of our research, we mainly focused on the primary contradictions that occur within the elements of activity systems (e.g. within the community) and secondary contradictions that arise between the elements of an activity system.

CHAT is based on Vygotsky's theory of learning and development (Vygotsky, 1978). As a theoretical framework for this research, CHAT provides a perspective for examining and discussing contradictions that emerged within and between elements of the activity system. This can help to point towards finding solutions while studying the relationships between cause and effect within the VLN's activity systems (Engeström, 1987). The first generation of CHAT is based on Vygotsky's concept of mediated action as the unit of analysis and focused on individual or singular activity systems (Zinchenkon, 1985, as cited in Engeström, 2016). Figure 3 illustrates the structure of the activity system in focus in second generation CHAT outlining the system components: Rules, Subject, Mediating Artefacts (Tools), Object, Division of Labour and Community (Engeström, 1987), and the relations between them.

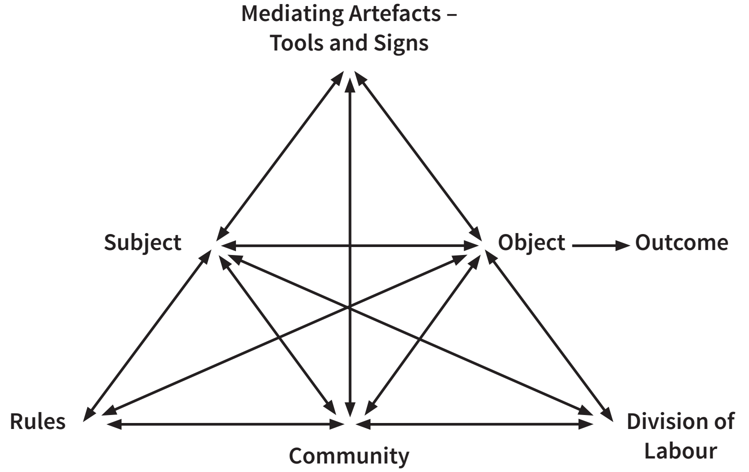

Figure 3: *The structure of a human activity system (Source: Engeström, 1987, p. 78)*

The use of second generation CHAT, applied to each VLN, enabled us to review and analyse VLNs as activity systems emerging within their cultural-historical contexts. Within this process model, we identified which components, such as the Community, Rules, Tools and Division of Labour, have the most profound impact on the Object of activity and the Outcome of the activities (Engeström, 1987). Through such an analysis, we were more able to develop and describe a clear picture of the Object, in this case, knowledge dissemination and uptake, the Subject's ability to enact intentional agency to achieve their shared or partially shared object, how the characteristics of the surrounding Community, and the Rules and Tools influenced the object (Bødker, 1990).

Research methodology

Phase 1: Primary data collection – Contextual profiling, Net-mapping and interviewing

The first step was to identify the VLNs to focus on in the study. We identified four VLNs that were being supported in the ELRC and in which two authors of this article were centrally involved in establishing and/or supporting; thus, they had first-hand experience of the VLNs and were also supporting members of the VLNs. The networks are:

- Amanzi for Food Learning Network, national/regional (AfFLN)
- Sustainability Starts with Teachers, national/regional (SST) (focus on Eswatini)
- Imvotho Bubomi Learning Network, Eastern Cape (IBLN)
- Sinakekela Sibusiso Semati Learning Network, Mpumalanga (SSSLN)

Besides familiarity with the VLNs, we decided to investigate these four VLNs due to their established nature and diverse geographic representation, facilitating a comprehensive analysis. Furthermore, all selected VLNs share a common object centred around the dissemination of environmental and sustainability knowledge. Three of the VLNs focus on sharing sustainable agricultural knowledge (AfFLN, IBLN, SSSLN), and one focuses on education for sustainable development practice in teacher education (SST), in particular in Eswatini. Three of the VLNs (AfFLN, SST, IBLN) were still active at the time of writing the report, while the fourth VLN (SSSLN) was dormant. The IBLN and SSSLN were started as face-to-face networks following in-person courses that later became VLNs, while the SST (Eswatini) and the AfFLN were started as virtual networks following online courses that were extended by VLNs.

The methodology consisted primarily of qualitative data collection and analysis involving contextual profiling of each VLN using historical data, as well as data obtained through geolocation mapping, and use of a social network mapping tool as well as a WhatsApp Network Group Chat Analysis. Net-Map is a user-friendly tool for mapping social networks, aiding grassroots educators in fostering place-based, action-oriented learning initiatives in environments lacking conventional support structures (Meterlekamp et al., 2021). We also conducted interviews with 25 members of the VLNs.

Interviews

The sample of 25 participants comprised ten members from the IBLN, seven from the SSTLN, five from the SSSLN, and three from the AfFLN, representing each of the four VLNs. The interviews sought to identify, from the perspective of the VLN subjects, the key factors or contradictions that influence the sustainability of the networks, how members see their role and how members feel they benefit from the networks. We also attempted to establish if transformative learning and knowledge dissemination occur within the networks and at what levels.

Telephonic and WhatsApp interviews were conducted. Interviews were recorded through an MP3 media recorder, including a Zoom field recorder or an MP3 recorder mobile app. Ethics clearance for the research was obtained through the Rhodes University Educational Ethics Committee. Learning network members, recognised as research participants, were asked to complete an informed consent declaration Google form before the interview. Participants received a copy of this declaration via email. The interviewers also requested verbal consent from the participants and explained the purpose of the research and what was expected of participants before the interviews.

Geo-mapping of networks

Using the data collected from the network members, we employed geolocation mapping techniques to construct visual representations for each Learning Network. Member locations and organisation data derived from existing records or from a survey sent to the VLN members were used to meticulously plot the locations of network members to provide a comprehensive visualisation of their spatial distribution and interactions within each Learning Network. The geolocation mapping was constructed using Google My Maps. These maps offer an important, nuanced understanding of network dynamics by illustrating the geographical distribution of actors within each network, thereby shedding light on how these networks function across different locations.

Net-Map Social Network Map

Drawing on the Net-Map Social Network Map tool, we constructed our network maps of the four VLNs from interviews, our network knowledge, WhatsApp Group data and previous research conducted by Lotz-Sisitka et al. (2022). We used the data to identify the location of each member and the organisation they represent, guided by the Net-Map Social Network Map framework. Net-Map, introduced by Schiffer and Hauck (2010), was designed to provide a comprehensive understanding of multi-stakeholder networks by gathering in-depth information about the Learning Networks, the actors' goals, and their influence on Learning Network system outcomes. This process facilitates the surfacing and visualisation of the invisible webs of relationships and knowledge dissemination among relevant actors within the network, offering a direct insight into their connections. We used the Net-Map, a social network map, as it allowed us to map relationships and the value within our case study networks to inform Learning Network activity systems. We could visualise and understand the subjects involved in the Learning Network, the links between the actors and how the network of actors operates in a learning capacity as they relate to the shared object of activity (Meterlekamp et al., 2021).

WhatsApp Network Group Chat Analysis

We analysed available WhatsApp data of the VLNs (using a sample of 2023 data in three cases), as this data provided insight into networked relations, as well as insights into the shared object as well as contradictions. For the WhatsApp Network Group Chat analysis, we used Python Programming. First, we exported the chat data from WhatsApp in a compatible format, such as CSV or TXT. Then the data was pre-processed by removing irrelevant information and organising members' messages into a structured dataset. Pandas, a Python data analysis library, was used for data manipulation to extract insights such as user interactions, message frequencies and network centrality measures. Findings were analysed and interpreted to draw conclusions about communication patterns, influential members, and overall group cohesion within the WhatsApp network (Iduh, 2020; Patka et al., 2023). Through this analysis, one can gather data that provides the basis for statistical analysis, activity maps, 'wordclouds', the most active users, the most used terms, emoji analysis, and more. However, we only captured specific data relevant to this research, including the number of monthly posts, most active days, most active users, and the amount and type of resources shared in an average month as these relate to the object of activity.

Phase Two: Data Analysis

Phase Two involved an analysis of the four Learning Networks using the second generation CHAT unit of analysis, namely the Activity System as outlined above. As shown above, the methodological approach embedded in the CHAT theoretical framework provided a useful systems approach to analysing the interrelationships and components within the VLNs as activity systems (Davydov, 1999; Engeström, 1987).

The activity system framework was used to organise the findings and identify the sources of tensions and conflicts within and between elements of the VLN activity system. Combining generic and specific analyses added depth to the process, with the four VLN activity system analyses pointing to shared issues, which helped to inform a more generic analysis across the four VLNs, although the intention was not to undertake comparative research. The reporting component of the analysis focused on capturing the key findings and presenting these in the form of recommendations that can shape further expansive learning options for the continuation of VLNs and their support, helping ELRC teams and the VLNs to engage productively with arising contradictions. Figure 4 outlines our research methodology.

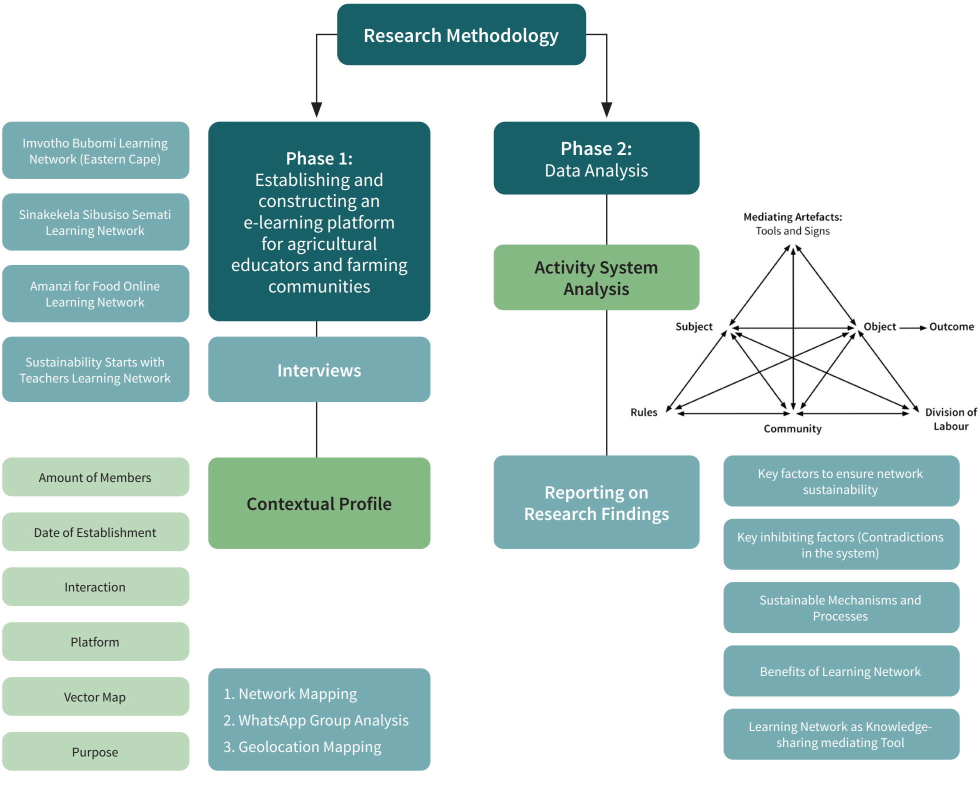

Figure 4: *Model of research methodology*

Findings and discussion

Contextual profiles and activity systems

We developed contextual profiles and activity system diagrams to investigate all four VLNs. The contextual profile and activity system analysis allowed us to better understand the histories, elements and interactions in these networks. These are briefly presented below, each with their activity system diagram and maps.

Amanzi for Food VLN (AfFLN)

The Amanzi for Food Virtual Learning Network (AfFLN) was developed as part of the Amanzi [Water] for Food project and training course activities, started in 2014 and still ongoing (Lotz-Sisitka et al., 2022). During the COVID-19 pandemic, the Learning Network went virtual, and the VLN WhatsApp group was created on 7 March 2022. At the time of the research, the network included 32 members from 18 different locations in Southern

Africa. The Object of this network is knowledge dissemination toward the Outcome of increasing Rainwater Harvesting and Conservation (RWH&C) practices and the uptake of knowledge on sustainable agricultural practices. The network aims to connect people and organisations and support knowledge dissemination among actors. This VLN functions mostly on WhatsApp, where members share their work and interesting articles relating to sustainable agriculture. The administrators, essentially the ELRC's Amanzi for Food project team, also organise Webinar meetings. The AfFLN is course-activated and is an online learning resource hub (https://amanziforfood.co.za/). The WhatsApp analysis (involving data from February 2023 - August 2023) shows that the Learning Network is often less active than expected. However, the analysis indicates that activity increases closer to webinar meetings. On average, 18 monthly messages are sent on the group platform, and four resources are shared. Our analysis also indicates that only four of the 32 members send 60% of these messages. Figure 5 describes the AfFLN as an activity system.

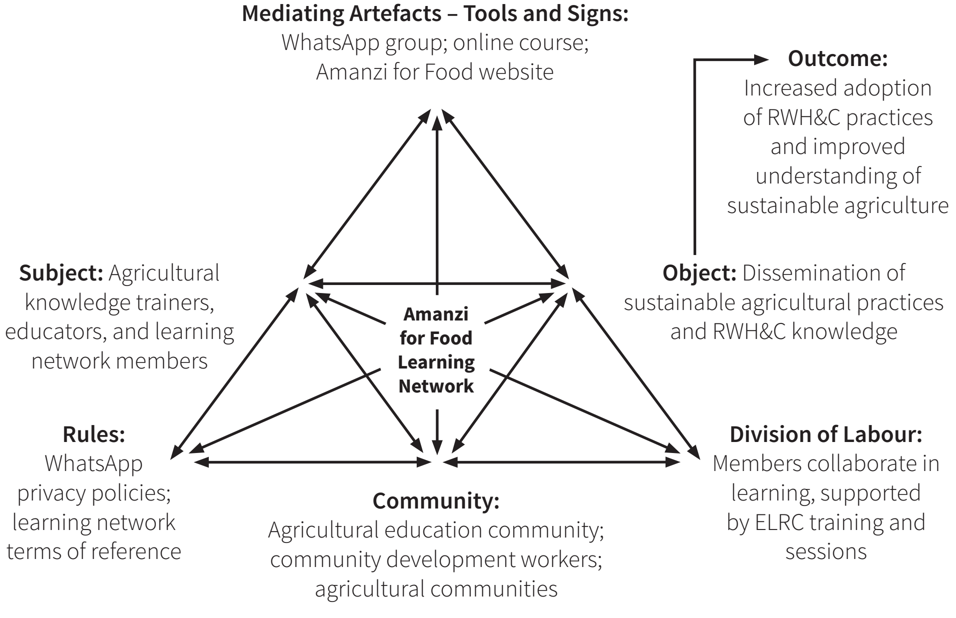

Figure 5: *The Amanzi for Food Virtual Learning Network analysed as an activity system*

Sustainability Starts with Teachers (SST) is an advanced capacity building programme extending across 11 countries in southern Africa. It was supported by a regional course that was initially offered face-to-face, and during COVID-19 was facilitated online. A series of Virtual Learning Networks (SSTLN) were developed to support teacher educators in higher education institutes (HEIs) to complete and extend their learning from the course.

This analysis focusses only on the SST network involving the participants in Eswatini during their enrolment for the UNESCO SST Online Course. The network continued after graduation. The overall objective of the SST programme is to provide capacity building to support teacher educators in integrating Education for Sustainable Development (ESD) into all areas of education. The Eswatini SSTTLN was established on 27 April 2021 with 71 members from 17 different towns in Eswatini. The WhatsApp analysis (data from February 2023 - August 2023) established that about 53 posts and 16 resources are sent on average per month on this VLN. The analysis identified six key members who send 49% of these WhatsApp messages monthly. Figure 6 shows this VLN as an activity system.

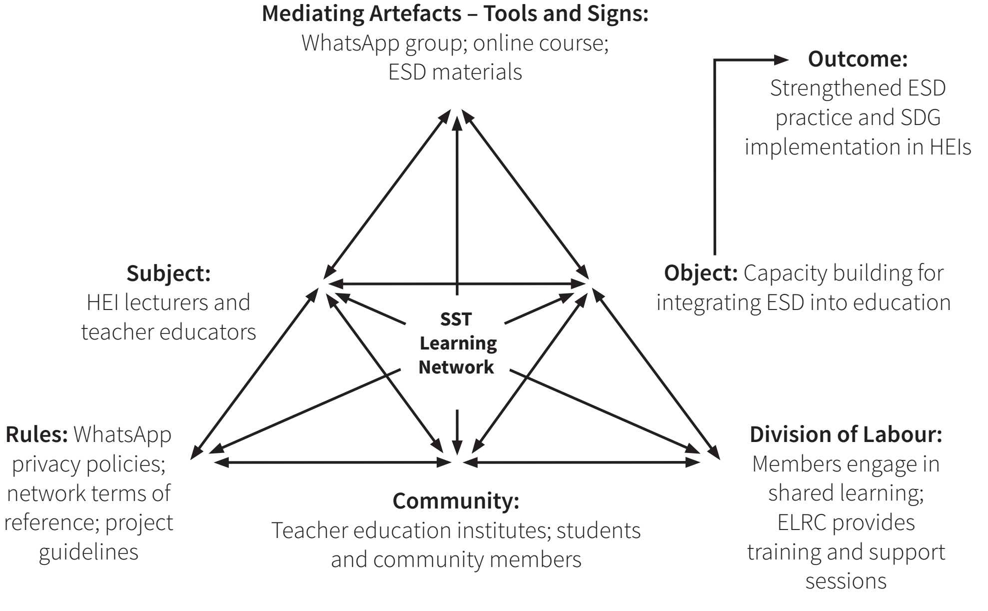

Figure 6: *The Eswatini SST VLN analysed as an activity system*

The third Learning Network is the Imvotho Bubomi Learning Network (IBLN), located mostly in the Nkonkobe municipal area in the Eastern Cape, South Africa, and at the time of writing, it had 102 members. It was established in 2014 from the Amanzi for Food Training of Trainers (ToT) course, which was offered a few times in face-to-face mode, with the Fort Cox Agricultural and Forestry Training Institute (FCAFTI) becoming a strong hub for the IBLN. The network aims to connect smallholder farmers and organisations, make information on rainwater harvesting more accessible, and encourage the increased use of rainwater harvesting and conservation (RWH&C) activities for food production. The IBLN also carries wider information on sustainable food production, with its Object expanding over time from an initial focus on RWH&C to include agro-ecology practices more broadly.

According to the WhatsApp analysis (data from January 2023 - August 2023), approximately 133 posts and 33 resources are posted monthly, with 39% posted by five Learning Network members. Figure 7 shows this VLN analysed as an activity system.

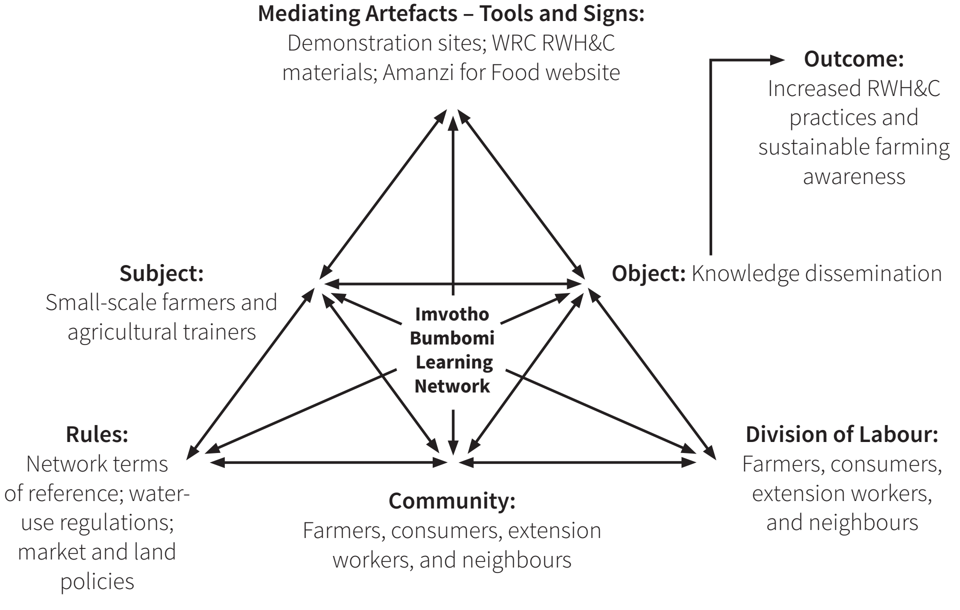

Figure 7: *Imvotho Bubomi VLN analysed as an activity system*

The last VLN we investigated was the Sinakekela Semanti Sibusiso Virtual Learning Network (SSSLN) that evolved from the Amanzi for Food Training of Trainers course facilitated by the ELRC with the University of Mpumalanga (UMP) in 2018-2019. The majority of the 16 members of the SSSLN were educators or extension officers or working in NGOs supporting farmers; thus, they all have a learning facilitation role of some kind or other. Most had formal qualifications in agriculture or extension. However, like most extension officers who had received formal training, their knowledge of RWH&C was limited, as the curriculum of most of the Agricultural training institutes is focused on large-scale commercial farming and expensive irrigation systems. At the time of this research, this VLN was no longer active, but this provided an opportunity to interview some members to find out why this was so. The interviews provided valuable insight into the decline of some networks. Figure 8 outlines the SSSLN Learning Network analysis as an activity system.

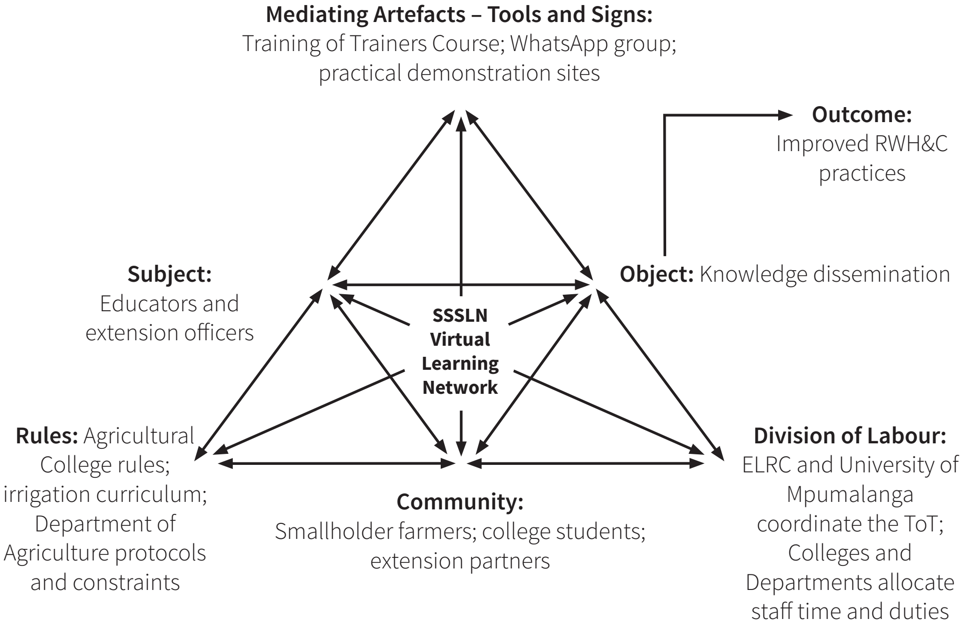

Figure 8: *Sinakekela Semanti Sibusiso Virtual Learning Network VLN analysed as an activity system*

Findings: Contradictions in the system – Key factors inhibiting functionality of Virtual Learning Networks

Our findings revealed that several contradictions occurred within and between the elements of the VLN activity systems. These contradictions included challenges relating to the activity system elements: Tools, Rules, the Outcome of the activity systems, Division of Labour, and Subjects. We lift out the main contradictions that were found to influence most of the VLNs in the discussion below.

Tools: Connectivity and digital infrastructure challenges

As the VLNs interact on online platforms, sound internet connectivity and digital infrastructure are fundamental for members to interact, which shows a contradiction in the tool (i.e. its intention to be accessible but the realities of data connectivity and costs not making this possible). During our interviews, we realised that many members are struggling with technology access limitations that make it difficult for members to participate. These include:

- High cost of data
- Lack of Wi-Fi infrastructure

- Limited network in rural areas with low mobile phone coverage
- Load shedding that affects mobile and data connectivity.

> "Data and lack of connectivity and networks in rural areas really kills learning networks." *– Participant 17, a member of the IBLN network*

A member of the SST team noted that data is extremely expensive in Eswatini and that there is little Wi-Fi access, even at some of the higher education institutes. She also pointed out that even though we think that most people are connected online, not everyone enjoys working on mobile phones, and such individuals tend not to participate in the virtual learning network platform.

> "Data constraints are a problem and also some people do not like mobile phones." *– Participant 20*

> "Data is very expensive." *– Participant 21*

Rules affecting the exchange value of the community

Even though VLN protocols have been established, some members still raise concerns about their privacy. Learning Network members we interviewed suggested that members are often reluctant to share information on the virtual network, affecting the community's exchange value. Members cited feeling uncomfortable sharing their opinions on the Learning Network WhatsApp group due to their lack of personal acquaintance with other members or uncertainty regarding whether sharing or commenting aligned with their role in the network.

Outcome of the Learning Network needs to be reassessed

The Outcome of a VLN is often the common goal that all Subjects are aiming to achieve. However, as time continues and the Learning Network members' needs change, the initial outcomes or goals of the Learning Network need to be reassessed. Members of the networks expressed concern that the Learning Networks do not cater to their current needs and do not support the members in continuing to learn and grow as the network did in the initial phases.

> "People need to feel they are learning and growing through the network." *– Participant 7*

> "Learning network must check on current agricultural trends, and challenges being faced by farmers." *– Participant 17*

Another member of the SST Learning Network also mentioned that when there is a purpose or an incentive, people become more active in the VLNs. This also supports the notion that many Learning Networks established as part of an initial Training of Trainers programme become less active after the members' graduation. One of the SST Learning Network

Regional Group Managers explained how difficult it was to keep the network active once the members had completed the SST course. However, another SST member explained that she thinks the best way to ensure a VLN stays sustainable is to carefully plan activities to engage Learning Network members in an ongoing way. This shows a contradiction in the Subject's motive and the object, and points to the need for ongoing interaction using Tools that are relevant and engaging over time.

In the Amanzi for Food VLN established to support and extend the online training following COVID-19, there has been a decline in member engagement and activity. Only a few members are continuously active, but most of these members are from the ELRC, the institution which initiated the Learning Network. Recent experiences with this network suggest that there can be little positive response, even following conscious efforts to agree on a focus on relevant and engaging activities for network members. There are also limited responses to posts specifically requesting these, thus it seems that there is a contradiction between the Tools and the Object of activity.

Division of labour: Role of network members

There are clear contradictions in the element of the Division of Labour. We perhaps assume that members should understand their roles through the Learning Network protocol and interactions. However, many interviewees stated that they do not have a role or are unclear about their purpose in the Learning Network. For example, when an Amanzi for Food Learning Network member was interviewed about his role, he commented that he did not have a specific role. Another member commented that her role is unimportant.

> "I do not have a specific role." – *Participant 5*
>
> "My role is not that much significant." – *Participant 13*

Not having a purpose or role in a Learning Network presents a contradiction in the existing division of labour and the intended division of labour which aims to enable everyone to share information with each other. However, some members are not keen on taking any formal role within a network and would rather stay in the background. Some interviewees also explained that members do not always understand how to participate. Sometimes, members are too busy to participate in network activities, which can render the network less functional than it could be. While the challenge posed by members not having time or losing interest in a Learning Network can sometimes be linked to a lack of a clear collective purpose, it can arise even where there is an apparent direction and purpose. In such cases, there may simply be a clear lack of motive to contribute to the shared Object, even if there is some interest in it shown by the initial participation of the member in the network.

Discussion: Virtual Learning Network's activity levels and sustainability are affected by these contradictions

The contradictions that emerged within and between the elements of the activity systems in the study were manifested in diverse forms, such as frustrations, uncertainty, difficulties and challenges. These contradictions provide a clear picture of why there are challenges in keeping VLNs active and sustainable.

From the WhatsApp data analyses, it was evident that in each of the VLNs a few members participated and contributed more than others. Further investigation is needed to determine if having a few people dominating the network helps others or discourages them from contributing. While network administrators constantly try to find ways to encourage all members to participate actively in the VLN, the results show that this does not always occur. It appears though from the historical analysis of WhatsApp data in the earlier period of the Amanzi for Food network (Lotz-Sisitka et al., 2022) that a mix of on-site and in-person activity and online VLN activity helps to diversify the VLN activities and contributions which has implications for how such programmes are supported. Analysis of WhatsApp data from the wider SST course (Van Staden & Lotz-Sisitka, 2023) also shows that when there are specific activities hosted, most often closely linked to the actual courses on offer, then more VLN activity emerges i.e. the motive for learning and knowledge exchange seems to be specifically focussed.

Looking at the contradictions within the system element of Tools, the issue of data cost was not unexpected, as data costs are a challenge in southern Africa. It is also important to note that VLNs have constraints relating not only to data cost but also to connectivity issues, digital literacy challenges and mobile device constraints. These challenges can make it more difficult for people unfamiliar with virtual networks, such as older adults or people in rural areas with poor connectivity, to benefit from VLNs. The contradiction is that the tools we use to keep our VLNs active come with structural challenges. Learning Network members require support to overcome these digital challenges and data constraints, and in one case in the Amanzi for Food Learning Network, one solution was to support a local 'ICT hub' where communities could gather and use the ICT tools. In some of the SST cases, the solution was to undertake activities where institutional Wi-Fi systems could support data, or we also used a SIM control data sharing solution to provide data, but this has its own challenges and costs.

In the analysis of the Rules element, it became clear that not everyone is comfortable sharing or being part of a discussion on a virtual learning platform. So, even though the Learning Networks have specific protocols in place, many members are too shy or uncomfortable sharing on the virtual platform. This contradiction constrains the exchange value of the community. Creating spaces where people feel comfortable sharing online or participating in discussions is important. Mixing online and in-person learning network events is also a possible solution as this creates a diversity of options for multi-voiced engagement, but this in turn can reduce the geographical scope of the networked interactions.

Through the contradiction analysis, it also became clear that the outcomes of a VLN need to be relevant to the Learning Network members' current needs. From the interviewee's comments, we noted that if one wants a VLN to be sustainable, the active members or leaders should identify relevant topics to discuss in the Learning Network and find ways for members to participate in collaborative activities towards common goals i.e. the object of activity and motive for engaging together in the object of activity needs to be well defined and regularly reviewed. For a VLN to be sustainable, its object must be reconceptualised as the members' needs evolve, and as the object itself transforms as was the case in the IBLN network. However, even if this is done, there is no guarantee of the sustainability or longevity of any network, and more work is needed to fully understand the reasons for their decline.

From the comments on the various aspects of the members' perceptions, it seems that although the VLNs are essentially intended to be non-hierarchical – something explained carefully to members – many people are looking for someone else to take the lead on the network activities. More often than not, it is the ELRC team that people look to for this leadership, while on the other hand, the team itself tries to avoid constantly taking the lead in the hope that the membership will step up. This is quite a complex contradiction, and it will take careful negotiation to resolve; it may require more careful shared and structured co-engagement around the Object of activity and may also require more careful consideration of the role of the learning institution in its mandated role, which is to support learning interactions. Perhaps the learning institution, in the tradition of CHAT research, should be clearer about its role as a formative intervention research partner, and engage more in mirror data production and sharing of analysis into the VLNs rather than mediated content.

Towards more sustainable Virtual Learning Networks

In our interactions with Learning Networks, we have noticed that VLNs have, despite their challenges, emerged as a means of acquiring and sharing knowledge in today's digitally driven world. The networks we investigated connect members of the agricultural and environmental sectors, including farming communities, educators, university lecturers, experts, and resources across geographical and institutional boundaries, offering unprecedented opportunities for inclusive lifelong learning. What needs further attention is how these processes can be strengthened to align more carefully with shared objects of activity.

Overall, as seen in our analyses, supporting sustainable VLNs requires careful consideration of various contradictions, all of which present as opportunities for further expansive learning. In conclusion, we share some suggestions on possible solutions, which can be considered within and across the ELRC's VLNs:

- Access to digital infrastructure, mobile connectivity and devices primarily revolve around the accessibility and affordability of smartphones or tablets and data plans. To address this issue, one can focus on sharing content that can easily be downloaded and accessed offline. This reduces reliance on continuous internet connectivity, making shared resources for learning more accessible.
- The topics for discussion and the Learning Network objectives should be relevant to the context of the members and need to be framed from a regular understanding of a shared Object.
- User-friendly platforms and strategies can be established or co-defined in which members feel safe and comfortable to share their knowledge and participate in discussions. A mix of online and in-person interactions could help people to feel more comfortable with each other and to communicate using VLNs.
- Administrators need to support the VLN by collaboratively planning activities that encourage knowledge sharing through the sharing of projects, online discussions and webinars that enable members to explore diverse perspectives and address the current challenges and contradictions they are experiencing in relation to their shared object.
- A monitoring and evaluation framework can be used to establish what type of activity, knowledge-sharing, and uptake occurs within the VLN to aid in mirror data production for sharing back into the VLN for reflexivity and movement
- Co-defined clear roles for each member are important and members need to be supported to co-define how they would like to interact with and contribute into the network. The essentially non-hierarchical nature of the VLN must be explained and that each member, whatever their position in their own organisation or the profile of their organisation, is entirely equal to all other members and that their contributions are all equally valued. Again, this can be facilitated by a clearer focus on the shared Object.
- The VLN should focus on building a community where members can discuss their challenges and seek guidance that creates a sense of belonging, and that leads to shared benefits and motives to expand the Object of activity. Here, accessible co-designed double stimulation tools can potentially assist.

The points above show potential expansive learning pathways for the ELRC and the VLNs it supports. While the analysis has primarily focussed on the contradictions that we have found in the VLNs, we note that participants have indicated that there are important advantages in the process of continuing to understand how to best support and co-create VLNs to address shared objects in the field of environment and sustainability education. These include the fact that the VLNs create platforms for dialogue and co-engagement on key subject matters relevant to the network members, help to strengthen synergies between all stakeholders to work together for a common cause or shared object. They also make available shared resources for problem solving and impact, whether being linked to research documents, conferences, seminars/webinars, other networks; and they offer shared spaces relevant to common objects and projects (e.g. RWH&C) that are not limited by geographic location. Thus, participants can share ideas and projects on the ground virtually and allow others to input on challenges or share in their achievements. The VLNs also have the advantage of enabling communities to work towards a common goal or shared Object. Contributing to this gives members a sense of belonging and purpose/accountability to keep the platform alive.

Conclusion

In an era defined by the rapid evolution of technology and the increasing interconnectedness of our global society, how we learn, share, and disseminate knowledge is undergoing a profound transformation. VLNs are emerging as potentially important platforms for the co-creation of shared activity, and thus as a powerful means of harnessing digital approaches to facilitate sustainable co-engaged knowledge dissemination within the agricultural and environmental education sectors around shared objects. However, our research found that this potential is not yet being fully realised. It is not always easy to ensure a VLN's sustainability and there is a need for ongoing expansive learning to strengthen and grow VLNs. Access to network connectivity becomes vital, as disconnection impacts people's enthusiasm. Members who have never met face-to-face can sometimes find it difficult to connect virtually. Therefore, careful consideration and planning are needed to ensure the sustainability of a VLN. Overcoming mobile device and data constraints, identifying key members who wish to take up leadership or administration roles, and ensuring personal comfort and psychological safety are vital for the success of VLNs. Addressing relevant topics that relate clearly to the shared object of activity, working with members to confront contradictions and challenges, and establishing clear roles for each member within the network helps create and maintain a knowledge dissemination community. By incorporating these mechanisms and processes, we can move closer to creating an equitable and accessible environmental and agricultural education system that benefits members of all backgrounds and ages, and that can help to advance their shared objects.

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Percentage contribution

Areas of contribution	Author	% Contribution per area, per author (each area = 100%)
Conception or design of the paper, theory or key argument	Van Staden	40%
	Sisitka	30%
	Lotz-Sisitka	30%
	Ntshudu	0%
Data collection	Van Staden	30%
	Sisitka	10%
	Lotz-Sisitka	30%
	Ntshudu	30%
Analysis and interpretation	Van Staden	30%
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Critical review of paper	Van Staden	30%
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