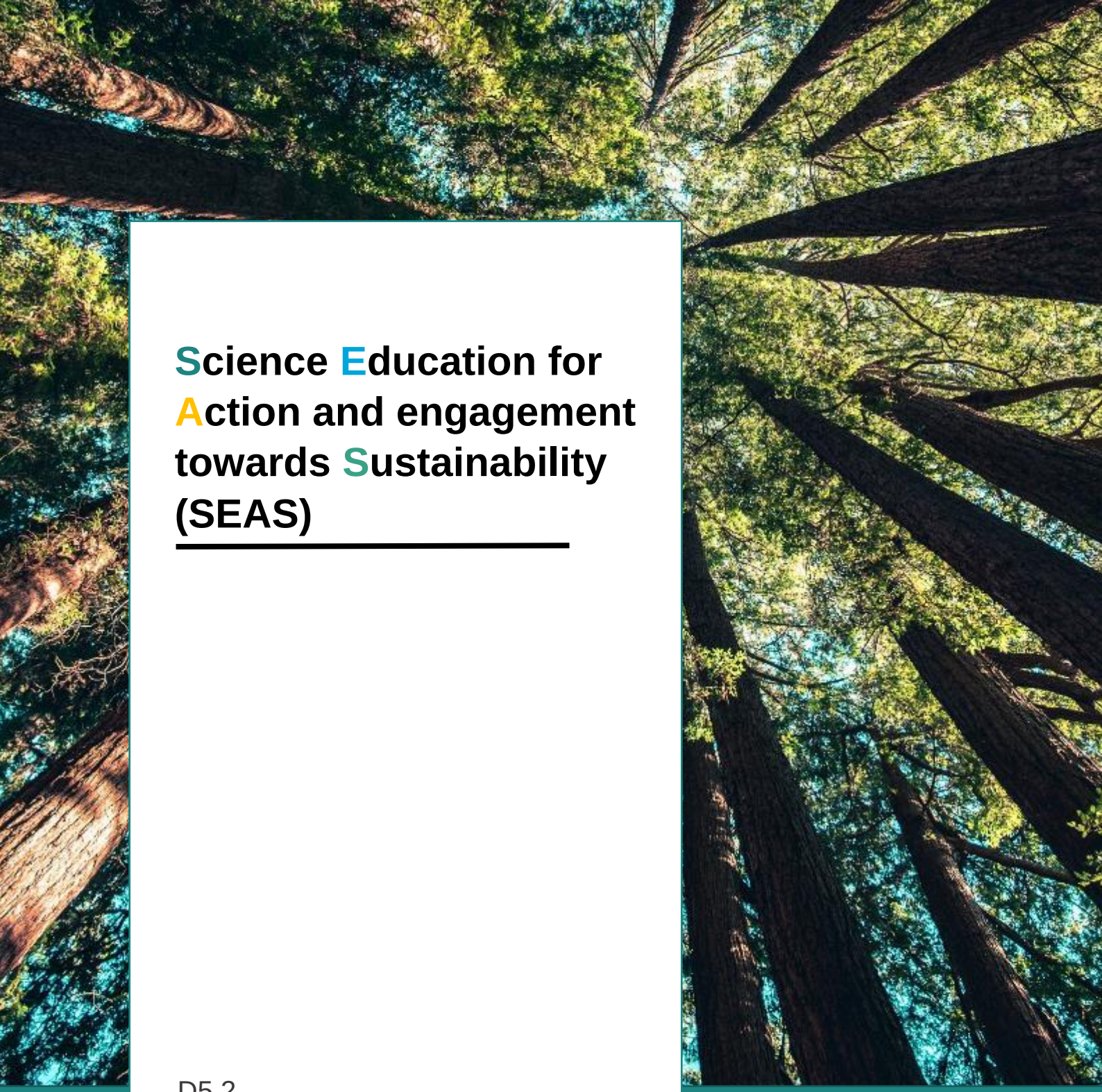


Science Education for Action and engagement towards Sustainability (SEAS)

D5.2

Report on models for the establishment and implementation of open schooling partnerships

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1. Summary

This deliverable reports on a global assessment and synthesis of insights regarding the establishment and implementation of open schooling partnerships that emerged from the six local SEAS open schooling networks in Austria, Belgium, Estonia, Italy, Norway, and Sweden. After describing this document's history and authorship (section 2) and situating it in the purpose and strategy of SEAS' global assessment and synthesis (section 3), we subsequently describe the following models for the establishment and implementation of open schooling partnerships:

- Transdisciplinary Education: a conceptual model for open-schooling activities
- LORET – Locally Relevant Teaching
- A multi-level perspective on sustainability transitions
- From the (re-)construction of knowledge to the construction of open schooling network
- On the roles of SEAS tools in facilitating open schooling and scientific literacy in the context of sustainability
- A Cultural-Historical Activity Theory Perspective on open schooling innovations

2. Document history and authorship

This document has been prepared by WP5 leader (Katrien Van Poeck), with contributions from all local network leaders as well as the leaders of WP2-3 (Alfredo Jornet) and WP4 (Stefan Bengtsson) and the SEAS project coordinator (Erik Knain). Below (section 3), we describe the strategy for global assessment and synthesis and, in particular, our approach to facilitate goal-oriented coherence between, on the one hand, the local assessment (WP3) and the work on tools (WP4) conducted in the six SEAS open schooling networks and, on the other hand, the global synthesis resulting in models for the establishment and implementation of open schooling partnerships. Here we briefly outline the writing, reviewing, and editorial process that resulted in the D5.2 document.

A first draft of the document was circulated to the project members on the 21st of January 2022 and was meant as a template for collecting input from SEAS partners. The document was drafted by Katrien Van Poeck and discussed in a meeting with Alfredo Jornet, Stefan Bengtsson and Erik Knain (21/01/2022). During the Project Management Team Meeting (PMT) on the 2nd of February 2022, the draft was presented for and discussed with the WP leaders and local network leaders. Particular attention was paid to further developing and integrating the sections on 'Synthesis of findings' ('Updating and differentiating SEAS concepts, tools, and methods' – 'Conceptual model(s)' – 'Identifying Dilemmas') in the local assessment report D3.2.

By the 15th of March 2022, SEAS partners submitted drafts of descriptions of models for sections 4 and further. The aim was to obtain a clear and somewhat elaborated view on the content of this report on models (i.e. of sections 4 and further), on how each topic (model) would be developed, and by whom. Feedback on these drafts was provided in written form by the 31st of March 2022. This will be done by a group of D5.2 reviewers (SEAS partners), including the WP5 leader. Part of

this review and feedback round was also to identify potential overlap and possibilities for integration and/or cross-references. During the PMT meeting on the 6th of April 2022, the drafts and feedback was discussed in view of sharpening, finetuning, and integrating the contributions.

By the 30th of April, full texts were provided for each contribution to (i.e. section of) D5.2. This served as input for the global assessment and synthesis workshop during the SEAS consortium meeting in Innsbruck from the 4th to the 6th of May 2022. During this workshop, we discussed all the models separately in order to provide the authors with additional feedback and we discussed the overall collection of models and the co-construction of the report.

The PMT meeting on the 1st of June provided us with a last chance for reviewing, giving feedback, and discuss the different sections of this deliverable. We organised this in the form of 'consults', creating time and space to raise questions, doubts, ask for advice, etc. on each of the models (sections). After receiving the final texts by the 15th of June 2022, WP5 leader Katrien Van Poeck conducted the final editing of this report.

3. Introduction

SEAS aims to create knowledge in three areas: 1) the establishment and implementation of open schooling partnerships; 2) transformational engagement scientific literacies and motivation; and 3) teaching and learning scientific literacy. This 'object of knowledge' is addressed from a variety of perspectives in the six different local networks: very diverse 'objects of study' (practices/experiments across the local networks) as well as divergent theoretical approaches and analytical methods guided the local assessments. In order to use this rich (empirical, methodological and theoretical) diversity as a strength, we designed an approach to co-construct the global synthesis deliverables that allows to do justice to the local diversity while also making sure that each contribution is relevant and helpful to realise our joint goal, i.e. to create knowledge on our shared object of knowledge (SEAS concepts and tools related to the three areas).

In the second annual local assessment report (D3.2), each local network was asked to summarise the local assessment findings in the form of conceptual models related to each of the three reporting areas. This diversity of models is assembled and integrated in the WP5 deliverables and, thus, in this report on models for the establishment and implementation of open schooling partnerships. As a whole, the work towards the three reports on models related to SEAS' assessment areas (D5.2, D5.3, and D5.4) was set-up to cover all SEAS' concepts, tools, and methods (see D2.2). With this in mind, the WP5, WP3 and WP4 leaders provided repeated intermediate feedback during the local assessment work and reporting. In addition, local networks were requested to identify how their findings and/or conceptual models contribute to scholarly debates on given dilemmas characterising the field of open schooling for sustainability in research fields such as sustainability education or science education.

The thus developed, diverse models and dilemmas related to the establishment and implementation of open schooling partnerships are described in this report with the aim to provide educators,

policymakers, researchers, etc. with guidance that helps them to reflect upon, discuss and develop their own approaches to open schooling in view of action and engagement for sustainability. One of the most important challenges in coordinating and supporting open schooling for improving science education for all citizens, involves ensuring the productive and sustainable collaboration across the different partners within each network. Different institutions and groups of participants have different backgrounds and interests. Coordination and support is needed to help establish shared goals and methods. This report provides insight into the challenges and opportunities that have emerged at the interface of the school and the out-of-school contexts as well as fruitful ways of handling these.

4. Transdisciplinary Education: a conceptual model for open-schooling activities

Author(s): Kubisch, Susanne and Lars Keller

Keywords/tags: transdisciplinary education in open-schooling, co-design, critical thinking, reflexivity, scientific literacy as/for transformational engagement

Aims & focus:
The model of Transdisciplinary Education aims at guiding the initiators of open-schooling activities, like teachers, out-of-school-partners or educational researchers, to develop open-schooling activities in a modular structure, basing on the didactical principles of moderate constructivism and inquiry-based learning. Furthermore, it aims at point out how to integrate these modules in current school curricula as well as discuss chances and challenges and therefore motivate policy makers to rethink and find solutions for the barriers for open-schooling activities.

Target audience:
teachers, out-of-school partners of different fields, educational researchers, policy makers (educational context)

In regard to the challenges of our time like anthropogenic climate change (CC), the involvement of the public in research processes has received increased attention by scholars in the field of transdisciplinary research (IPCC, 2021; Lang et al., 2012; Stauffacher et al., 2008). Scholars in the field of citizen involvement distinguish between different major arguments, which pledge for an active involvement of citizens. One argument, is that citizens, especially, concerned and affected people, are the best experts in respect to their problems, needs and interest (Fiorino, 1990; Stauffacher et al., 2008). Moreover, policy documents like the Agenda 2030 with the Sustainable Development Goals (SDGs) and Education for Sustainable Development (ESD), point out the significance of education in empowering people of all ages to contribute to a sustainable future (UN, 2015; UNESCO, 2017, 2021). The probably most affected group by todays and future challenges are young people (Corner et al.,

2015). At the same time, young people are those, who are excluded from decision-making processes today (Brundtland, 1987). Open-schooling has potential to fulfil both the claims of transdisciplinarity (Lang et al., 2012) and a transformative education, how it is demanded by ESD (UNESCO, 2021), to empower young people in formal schooling to contribute to a sustainable future, their future.

Developing and building on the concept of transdisciplinary education (TE) (Susanne Kubisch et al., 2021) which is aligned to the principles of transdisciplinarity (Lang et al., 2012), the Austrian local network, which is one of the open-schooling networks in SEAS, provides an example, demonstrating how open-schooling can be fruitfully implemented in formal schooling.

4.1. Chances and challenges of Transdisciplinary Education

Research in the realm of TE and transdisciplinarity in education show that partners at both sides – science and society - can benefit from collaboration. Findings of the implementation of TE in Austria show for example a high learning effect of the modules with a high degree of transdisciplinarity and inquiry-based learning, allowing students to actively engage with sustainability issues and promote exchange with out-of-school partners (Keller et al., 2019). Moreover, a study by S. Kubisch et al. (2021) points to a mutual learning effect between all partners involved in TE. Other studies within the network show the increase of student's self-efficacy in regard to climate protection (the feeling of being able to contribute to climate protection) as well as pro-environmental behavior in different fields (Deisenrieder et al., 2020; S. Kubisch et al., 2021). A further study, emphasizes the promotion of all three visions of scientific literacy for transformational engagement through TE. Both scientific knowledge and processes, as well as critical thinking and engagement are fostered by TE (S. Kubisch et al., 2022). Studies of transdisciplinarity in education point beside mutual learning to transformative learning as an outcome of transdisciplinary collaboration (Mitchell et al., 2015). Joint research with out-of-university partners in higher education, moreover, demonstrate the improvement of students' research skills and the contribution to both system, target and transformation knowledge (Pearce et al., 2018). Additionally, Clark and Button (2011) demonstrate the contribution to students' critical thinking competence. These findings point for the promotion of TE in open-schooling partnerships and to its contribution to transformational engagement.

TE requires high organizational efforts, since besides the organization and design of educational activities the continuous exchange and temporal coordination with partners is significant. Furthermore, the acquisition of (scientific) experts can be challenging, since for example in the case of the Austrian local network, the experts voluntarily support the open-schooling network, hence they work in further institutions and particularly have to take vacation to support the network. Consequently, it is important to stay in continuous contact with (scientific) experts to dispose of a pool of experts. It is recommendable to organize the dates for the collaborative activities with teachers early in the year, so that the acquisition of (scientific) experts can start earlier. For the teachers who actively participate at the network, the organization of the collaborative activities can be challenging, being an extra effort to everyday teaching activities. Therefore, it is recommendable

for teachers, to communicate the collaboration aims to their colleagues and ask for support within school.

4.2. Transdisciplinary Education exemplified by the Austrian local network

The conceptual model of TE basis on the principles of transdisciplinarity (Susanne Kubisch et al., 2021) (see Figure 1). In transdisciplinary research activities, partners from science and society jointly do research on sustainability issues like for example CC (Lang et al., 2012). Societal partners, who are affected by a problem and who are the best to know their interest and needs and hence have different expertise and experience with an issue (Fiorino, 1990; Stauffacher et al., 2008), are integrated and co-design a scientific research process. Consequently, transdisciplinary research draws on an exchange of knowledge, experience, interests, aims and visions of science and society and generates opportunities for mutual and transformational learning as well as for societal and scientific literacy (BMWFW, 2015; Lang et al., 2012; Mitchell et al., 2015; Walter et al., 2007). Moreover, due to the continuous exchange of perspectives, transdisciplinary research is highly integrative and reflective. Concluding, transdisciplinary research aims at having a social impact and at being transformative (Lang et al., 2012)

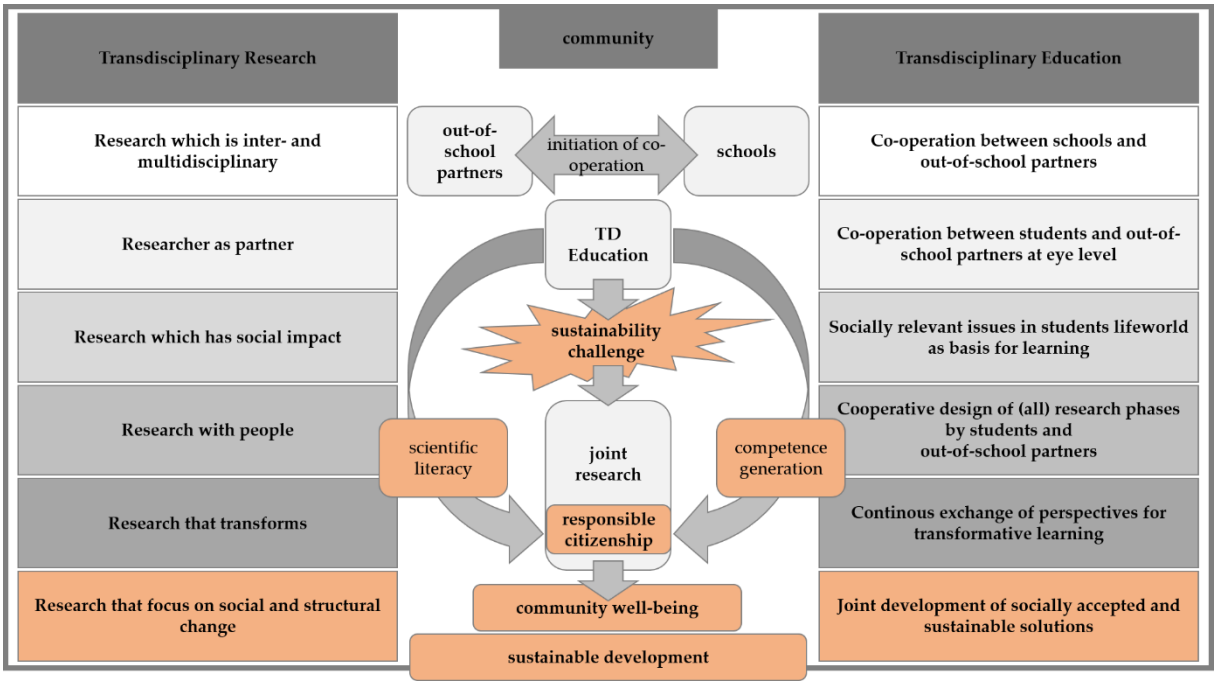


Fig. 1: From Transdisciplinary Research to Transdisciplinary Education, source: (Susanne Kubisch et al., 2021)

The concept of TE, which was developed within the context of open-schooling is aligned to the principles of transdisciplinary research. It aims at contributing to the demands of a transformative education (UNESCO, 2021) by fostering research activities on sustainability issues between schools and out-of-school partners (Susanne Kubisch et al., 2021).

In order to motivate students and give students a voice in designing their future, TE promotes collaboration on equal footing between researchers, students and teachers. Therefore, the didactical

approach of TE basis on a moderate constructivist understanding of learning (Riemeier, 2007), which comes from the assumption that learning is an active, situational, emotional, social and self-regulated and consequently constructive process. A moderate constructivist learning environment provides structure and support through teachers and researchers, and simultaneously gives students the space to follow their interest and co-design certain research phases (Reinmann & Mandl, 2006). The complex scientific research processes is reduced to its single phases, resulting in inquiry-based learning (Pedaste et al., 2015), where students jointly identify problems, formulate their own research question, generate hypothesis, collect data and find answers to their questions.

The collaboration with schools can start with the acquisition of schools and teachers by email and telephone. The teachers are hereby asked to take part at a teacher training, which is the basis for the open-schooling activities. A teacher training is important to get to know the collaboration partners and to discuss the structure of the educational activities and corresponding aims and tasks for teachers (see Figure 2). The teacher training is implemented by the Austrian local network team – scientific researchers of the working group of *Education and Communication for Sustainable Development*, at the department of Geography of the University of Innsbruck. The teacher training takes place in the respective out-of-school locations, in this case a High Alpine Mountain Area and consists of workshops, lectures and field trips with the aim that teachers get the opportunity to actively experience the concept of transdisciplinary education (Susanne Kubisch et al., 2021) and its underlying didactical approach (moderate constructivist understanding of learning (Duit et al., 2013; Riemeier, 2007; Widodo & Reinders, 2004), inquiry-based learning (Pedaste et al., 2015; Pedaste & Sarapuu, 2006) and inter- and transdisciplinarity (Lang et al., 2012)).

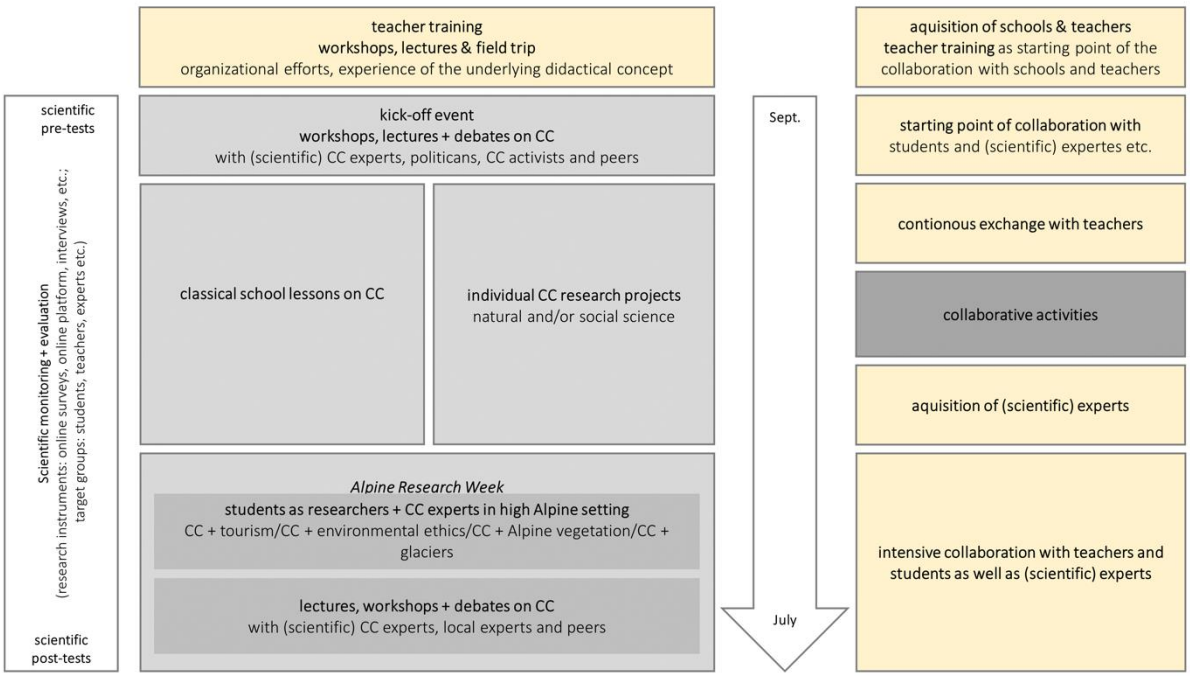


Figure 2. The modular structure of educational activities and corresponding collaborative activities, source: own modification of (Keller et al., 2019).

Before starting the collaboration with students, it is necessary to organize the dates, contents and tasks for the in- and out-of-school modules with teachers as well as the content of the in-school

learning modules which behove the teachers (*classical school lessons on CC*, *individual CC research projects*). TE is organized in a modular structure in order to provide students a balance between in- and out-of-school modules and to guarantee the integration of the modules in current school curricula.

After having organized collaborative activities with the teachers, the *kick-off event* builds the starting point of the collaboration with students. Aim of the event is that students get to know the team as well as the modules and tasks during the school year and have first discussion on equal footing with (scientific) experts and politicians about CC on local and global level. Furthermore, the event aims at capturing students' pre-conceptions about CC and motivate reflection about the own role in regard to CC protection. The task of the network team is to organize the content of the event, as well as acquiring (scientific) experts from different fields and politicians. The teachers need to organize the excursion to the module, which is located at an out-of-school location.

During the school year students have *classical school lessons on CC* in different school subjects and develop *individual CC research projects* (e.g. in the case of the Austrian network students collected mobility data and developed an initiative to convince students and teachers to go to school by bike; others collected climate data within a village and compared it to data within the city centre etc.). These two modules are organized and guided by the teachers themselves. During this time the network team and the teachers are in continuous contact to discuss still open questions and to support teachers if necessary. In case of the *classical school lessons on CC* it is important that teachers coordinate the content with teachers of other subjects and to involve and inform teachers who did not take part at the teacher training, in order to guarantee the implementation of the didactical approach. At the end of the school year, the *Alpine Research Week* takes place in an out-of-school setting in a High Alpine Mountain Area. Aim of the week is that students get to know the different facets of CC by actively engaging in doing research about CC in different fields and by exchanging perspectives and knowledge with (scientific) experts of different fields. The students go through different modules (e.g. tourism, environmental ethics, glacier, vegetation) which are linked to CC. Hereby they are supported by the respective (scientific) experts and a person of the network team, who are guided by a concept for the respective module. The concepts are designed in advance by the network team and base on the underlying didactical approaches. Hence, the concepts support students to follow their interest on the basis of inquiry-based learning (Pedaste et al., 2015) and simultaneously give guidance and structure. For organizing the week, teachers need to organize the excursion as well as the transportation and accommodation for the school and (scientific) experts, while the network team organizes the (scientific) experts and the program. Moreover, the network team provides and continuously further develops the concept for the *Alpine Research Week* and organizes the syntheses day at the end of the week, where students meet local experts, discuss about still open questions and reflect the last school year. The synthesis day is the end of the collaborative activities during one full school year.

Additionally, monthly online meetings are provided by the network team, where all participating teachers are invited to join to exchange experiences, support each other and raise still open questions.

Moreover, the network team collects data by means of a standardized online questionnaire at the beginning and the end of the collaboration, so that the learning effect and further factors like self-efficacy, responsibility and pro-environmental behavior can be continuously monitored. These findings also build the basis for the continuous evolution of the educational modules and collaborative activities.

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5. LORET – Locally Relevant Teaching

Author(s): Leif Östman & Katrien Van Poeck

Keywords/tags: LORET - Locally Relevant Teaching

Aim & focus:
This model aims to provide guidance to reflect upon and discuss how locally relevant, real-world sustainability problems can be used as a driver for fascinating teaching and learning. It can be used to develop open schooling through a series of workshops and preparatory assignments designed to support educators in developing lessons and out-of-school activities that address sustainability problems while, all the same, teaching subject knowledge as prescribed by the curriculum.

Target audience:
Teachers – teacher trainers – school coaches – NGO staff

5.1. Introduction

LORET (Locally Relevant Teaching) was invented by Leif Östman and Staffan Svanberg in 2004, while working on a project on education for sustainable development in Mongolia. Since then, it has been used in many countries in Asia, Africa, South-America and Europe.

LORET is designed to support teachers in using real-world problems relevant to the local community as a starting point for education. The guiding principle is to combine engagement with societal problems and the realisation of curriculum objectives and, in doing so, offer students unique educational learning opportunities and hope. Through LORET workshops, teacher teams develop a plan for implementing locally relevant teaching and design a series of lessons that take students along in an authentic sustainability problem-solving process.

In the SEAS project, the LORET-based open schooling in the Belgian local network was analysed by Ghent University and EduQuality (see D3.2) and resulted in the further development and refinement of the methodology as described below.

5.2. LORET workshop trajectory

LORET supports teacher teams an partners in open schooling collaborations by offering a step-by-step procedure to plan sustainable development teaching by addressing locally relevant challenges while, all the same, teaching subject knowledge as prescribed by the curriculum. This enables facilitators and teachers to collaborate effectively towards clear and tangible results while, all the

same, providing openness to tailor the LORET work to the specific context, needs, objectives and opportunities of each participating school.

LORET workshops are designed according to the principle of 'blended learning'. The trajectory consists of an alternation of meetings and preparatory assignments. Planning locally relevant sustainability teaching with LORET involves five workshop meetings, each prepared by the participants through an assignment carried out in advance. Before the first workshop meeting, a preparatory meeting is organised in order to tailor the LORET work to the school-specific context (see below). After the last meeting, LORET plans and lesson plans are uploaded on a digital library so that they can inspire other teachers and schools

Preparatory assignment 1: Identifying locally relevant sustainable development issues

The trajectory starts with preparatory work done by the teachers in the LORET team who list locally relevant sustainability problems. As decided in the preparatory meeting, this can be done with or without the active participation of students and/or local stakeholders. LORET offers frameworks and tools to support teachers in this work.

Workshop meeting 1: Turning sustainability problems into educational content – didactical carving

The participants select a sustainability problem from the list of identified locally relevant challenges and turn this real-world problem into educational content through a process of 'didactic carving'. That is, they 'carve out' of this massive societal problem a (sub)problem that will be suitable for the students to work with: a problem that is manageable and susceptible for the students and that bears the potential to take them along in an authentic sustainability problem solving process.

Preparatory assignment 2: Identifying fruitful resources for supporting the students' inquiry

The teachers make an inventory of resources that can help the students to address the problem? They list what the school subjects they teach have to offer in this respect as well as what the local environment, actors in the local community, organisations, media, etc. have to offer.

Workshop meeting 2: From inventory to planning

The participants present their preparatory work and construct a collective mapping of fruitful resources for supporting the students' inquiry. If the result is too much to address in one project or one school year, a prioritisation is made regarding which curriculum and local environment resources will be in focus in the LORET plan.

Preparatory assignment 3: Preparing a LORET plan

The teachers reflect on how they can design lessons in which their students first explore the locally relevant sustainability problem and subsequently generate possible ways to solve it. They identify connections to the curriculum goals they aim to address, determine the number of lessons they will spend on it and the content for each lesson, identify the teaching methods and activities, and

formulate ideas on how to collaborate with colleagues and organise the lessons so that the students can effectively integrate the knowledge from the different school subjects.

Workshop meeting 3: Creating a LORET plan

The participants present their preparatory work and bring it together in a collective overall teaching plan. The collective result is critically examined: Is the teaching content well-chosen? Do the chosen teaching methods and activities foster authentic inquiry? Are ecological as well as economic and social aspects of sustainable development covered? Are students stimulated to integrate knowledge from different school subjects? Will students learn theoretical/abstract knowledge and insights as well as practical skills, communication skills, inquiry skills, attitudinal aspects, ethical and democratic competences, etc.? Are there strong connections to the local community? Etc.

Preparatory assignment 4: Preparing a LORET plan – Part II

After performing the lessons planned in workshop meeting 3, the teachers reflect on how they can design lessons in which their students experiment with implementing (one/some of) the generated solution proposals and evaluate their problem-solving process. Each for their own teaching practice, they again identify connections to the curriculum goals they aim to address, determine the number of lessons they will spend on it and the content for each lesson, identify the teaching methods and activities, and formulate ideas on how to collaborate with colleagues and organise the lessons so that the students can effectively integrate the knowledge from the different school subjects.

Workshop meeting 4: Creating a LORET plan – Part II

The participants present their preparatory work and bring it together in a collective overall teaching plan. The collective result is critically examined: Is the teaching content well-chosen? Do the chosen teaching methods and activities foster authentic inquiry? Are ecological as well as economic and social aspects of sustainable development covered? Are students stimulated to integrate knowledge from different school subjects? Will students learn theoretical/abstract knowledge and insights as well as practical skills, communication skills, inquiry skills, attitudinal aspects, ethical and democratic competences, etc.? Are there strong connections to the local community? Etc.

Preparatory assignment 5: Document the LORET work

The teachers document their LORET plan and lessons – with the help of user-friendly templates – so that these can be shared and inspire other teachers. They reflect on what went well, what could be improved, and if there is any need/desire to follow-up the LORET work in a subsequent trajectory with the same or other students.

Workshop meeting 5: Looking back and looking ahead

In this final meeting, we share experiences and reflections, celebrate the joint achievements and discuss whether/how the LORET trajectory requires follow-up in the future.

5.3. Tailoring LORET to the school-specific context

LORET allows to work tailor-made, adapted to the school-specific context:

- The school team chooses the theme and focus for the work and LORET facilitators offer didactic tools and support in line with that.
- The school team decides with whom: Which teachers (and therefore subjects)? Which classes or courses? The whole school maybe? In collaboration with local partners? An abundance of possibilities…
- The school team decides when and how intensively: An annual theme? A project week? An integrated strategy? Choose what seems to be the best way of working for your school.

5.4. Practical aspects and expectations

In order to make the LORET-workshop efficient, the following practical arrangements are necessary:

- Before the start of a LORET trajectory, a formal commitment from the school is required.
- During the preparatory meeting with the participating teachers, which lasts about an hour, the facilitators inform the team about LORET, set dates for the meetings and make decisions on how to tailor the work to the school-specific context.
- It is important that the participating teaching team has the opportunity to gather for 5 meetings that take 2 hours each.
- Between these meetings, some time is needed to carry out the preparatory assignments.
- To provide time for the preparatory work, there are about 3 weeks between the meetings. Meeting 4 takes place after the lessons planned in meeting 3 have been performed.
- The meetings can take place digitally or in-person.
- A LORET teaching team can consist of 2-10 teachers.
- Participating in a LORET trajectory implies the commitment to upload the LORET-plan on the digital library in order to enable collegial learning.

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https://loret.se/

6. A multi-level perspective on sustainability transitions

Author(s): Katrien Van Poeck

Keywords/tags: LORET - Locally Relevant Teaching; Co-design for social innovation; SEAS Library

Aim & focus:
This model aims to provide guidance to reflect upon and discuss how open schooling practices may contribute to a transition of the educational system. It can be used to develop open schooling by identifying and describing promising niche practices as well as by identifying obstacles within the currently dominant education regime and possible ways to overcome these.

Target audience:
Teacher trainers – educational policymakers – sustainability policymakers – educational researchers – sustainability researchers

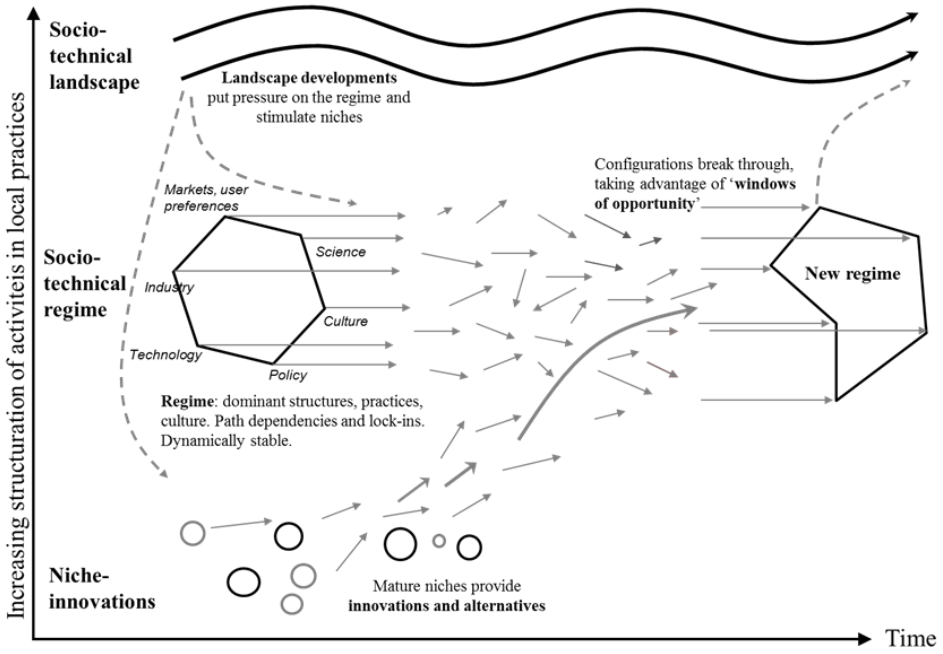
6.1. Introduction

In this section, we present a model for understanding how open schooling practices may contribute to a transition of the educational system. 'Transitions' have been characterised as fundamental changes in a societal system in the sense that existing structures, cultures and practices, that are anchored in a society, are broken down and new ones become dominant (Grin et al. 2010). This involves long-term processes of co-evolutionary changes in multiple dimensions: technology, actors, rules, infrastructures, power relations, patterns of thinking, problem definitions, cultural meanings, etc. Such complex, non-linear processes do not result from one single driver or cause but involve a complex interplay of different processes and factors (Geels 2012). This implies uncertainty and open-endedness: there are multiple transition pathways (Geels and Schot 2007), multiple promising innovations and initiatives in varied domains and it is impossible to predict which of these will prevail (Köhler et al. 2019).

6.2. The multi-level perspective

The multi-level perspective (MLP) views transitions as non-linear processes that result from the interplay of multiple developments at three analytical levels: socio-technical 'regimes', 'niches' and 'landscape' (Geels 2007, 2012, Geels and Schot 2007). A regime is the dominant way of fulfilling a societal function (e.g. housing, transportation, food) and consists of mainstream technologies, actor networks, rules, practices, artefacts, infrastructures, ways of thinking, etc. The interconnectedness of all these elements, it is argued, keeps the regime 'dynamically stable' (Geels 2005, p. 77). They function as lock-in mechanisms that provide strong steering. Although they leave some room for creativity and adaptation to new situations and for improving the dominant design of a system, this incremental change stays within the bounds of the existing regime. Radical novelties that diverge

strongly from what is normal in the regime are seen to emerge in niches. As spaces where 'non-conformism' (Rotmans and Loorbach 2010, p. 132) develops, niche configurations are less stable than regimes: they consist of technologies, rules and practices in-the-making. Whether niches are successful and influential, however, largely depends on evolutions at the other levels. The level of the socio-technical landscape is constituted by deep cultural patterns, macro-political developments, natural circumstances (e.g. global climate change) and material environments (infrastructures). This 'technical, physical and material backdrop' of society (Geels and Schot 2007, p. 403) is beyond the direct influence of regime or niche actors but makes some actions easier than others. Yet, it enables 'windows of opportunity' to open-up during which regimes may undergo profound change.



There are only very few examples described in research literature where the MLP has been used to study transitions in/of the educational system (Deleye et al. 2019). Nevertheless, it offers us a useful lens for discussing the findings of the assessment of SEAS open schooling experiments and for raising some promising prospects for future research.

6.3. Niche practices and obstacles of the dominant regime

In the Belgian open schooling network, an analysis of how LORET disturbs teaching habits and customs as well as the analysis of threats and opportunities related to the target audience of the library of lesson plans and teaching materials shows how both LORET and the SEAS library can be seen as niche practices that go against currently dominant practices, cultures, and structures in the regime of the education system (see D3.2 Local assessment report). Addressing real-world sustainability challenges relevant for the local community, taking students along in a quest for solutions for these problems, creating tailor-made lesson plans and teaching materials for that purpose, peer-to-peer co-creation, building on and continuously refining each other's work, etc. are not part of most teachers' habitual manner of teaching, nor of the usual customs in schools. As transition studies have shown, however, such niche innovations bear the potential to contribute to

a transformation of systems, despite obstacles encountered when confronted with the dominant regime. In order to explore the potential of the SEAS pilot experiments and the knowledge and tools developed through it to contribute to long-term, structural improvements, it is therefore valuable to illuminate the identified MLP dynamics and to outline some directions for much-needed future research on this topic.

Our analysis of how LORET disturbs teaching habits and customs shows a number of obstacles within the socio-technical regime of the current educational system that serve as barriers for change. They provide challenges for the establishment and implementation of LORET-based open schooling partnerships and for the upscaling and sustaining of its impact. These lock-ins and path dependency are what keeps the regime dynamically stable. Examples are the routine of relying on pre-fabricated teaching materials, the market in which publishing companies provide textbooks and thereby largely affect the concretisation of the curriculum, an existing library of lesson plans and teaching materials that almost holds a monopoly-position but does not offer sufficient opportunities for co-creation and continuous refinement, the lack of an established culture of and infrastructure for sharing and collaborating between teachers, the heavy workload of teachers, school governance and organisation that is largely built on monodisciplinary work, etc. There are, however, some so-called 'internal contradictions' within the regime that open-up opportunities for change. Think of, for instance, the increasingly pressing shortage of teachers, protests of parents against the costs related to textbooks, concerns about decreasing quality of education, school strikes for the climate that show how students demand more attention for sustainability education, etc. that all put pressure on the regime. Furthermore, we can identify several landscape trends that may contribute to opening up windows of opportunities (e.g. digitalisation, climate change), while others may have the opposite effect (e.g. new public management, economic crisis).

6.4. The multi-level perspective

This explorative multi-level perspective on how open schooling practices and partnerships may contribute to fundamental transitions in view of a more sustainable education system reveals promising pathways for future research. Our assessment that started from identifying and investigating the disturbance of habits and customs in concrete niche practices offers an alternative approach to most MLP-based studies that start from identifying general regime characteristics, landscape trends, and niches, often providing a static analysis (snapshot) of the socio-technical system under study. Multiplying these sorts of analyses in a variety of settings and contexts where niche experiments aim to overcome problems of the current educational system will allow us to identify fruitful ways to unlock lock-ins and tackle path dependencies. Future research should also pay attention to identifying so-called 'policy entrepreneurs' as well as opportunities for empowering them. Policy entrepreneurs are advocates of certain problems and solutions who are willing to invest resources (time, reputation, energy, money) to promote ideas for policy change and try to influence the decision agenda (Kingdon 1984). They try to create and respond to those moments when a problem receives attention and the political climate is receptive, thereby 'hook[ing] solutions to problems, proposals to political momentum, and political events to policy problems' (Kingdon 1984,

p. 182). Such research is much-needed to gain more knowledge on how transitions can be enabled and accelerated as well as to provide methods and tools for empowering 'change agents' to do so.

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7. From the (re-)construction of knowledge to the construction of open schooling network

Author(s): Giulia Tasquier

Keywords/tags: local open schooling model, ChangeLab methodology, Boundary crossing, FEDORA

Aim & focus:
This model aims to provide guidance to reflect upon and discuss a possible model of open schooling interpreted in terms of 3 dimensions of openness as possible dimension of actions, that are: Act at a level of content; Act at a level of interaction; Act at a level of (institutional) transformation. It can be used to develop open schooling by using the metaphor of trading zone and thinking the network as an experience of boundary crossing practices.

Target audience:
Educational researchers – teachers – teacher trainers.

4.1 Introduction

The current complex societal challenges require all citizens to better understand science and technology if they intend to actively and responsibly participate in knowledge-based decision-making and innovation processes, as asserted in the EC report "Science Education for A Responsible Citizenship" (EU, 2015). Always in this same report it is stated that ways of expanding science education beyond traditional school models must be created and explored, and the concept of ***open schooling*** is one of the key points emerging from it (EU, 2015).

Open schooling collaborations emerge as valuable means to address today's sustainability challenges, since they establish learning and knowledge-generating practices that are co-designed by and connected with members of different sectors, with different backgrounds and needs, and who meet and are connected to each other by their belonging to local, shared communities and places. However, open schooling requires integrated approaches to facilitate, organize, and document cross-sectorial collaboration towards the formulation and solution of shared local challenges. More specifically, methodological orientations are needed to ensure democratic and productive participation that can create models of open schooling.

The centrality of this communitarian aspect makes open schooling a locally-grounded and locally-oriented concept. In the light of this evidence, it is required to reason in terms of ***local model of open schooling*** that are highly influenced by contextual and cultural aspect. The locality feature of the model, however, will not prevent transferability and adaptability to other contexts.

The raw model of open schooling discussed here emerged from experiences, reflection and approaches grounded into the Italian context. Indeed, this description has the aim to show how the main concepts of SEAS projects were embedded into the Italian research perspective and how they shaped existing reference models.

4.2 A local model of open schooling network

Working on this area required an important shift within the UNIBO research approach. Indeed, the main issue encountered concerned the shift did in moving UNIBO research focus from the educational reconstruction of STEM content knowledge (Duit, 2007;) toward the creation of an open schooling network. Indeed, as research tradition our focus was mainly on the construction of "modules" that consisted in taking the discipline and re-shaping it by following some design

principles and ideas (Levrini et al., 2015). So, the focus was mainly on the discipline and on its multi-perspective and multi-dimensional nature, even if within previous projects this was experienced and carried out within communities of researchers, communities of learners and communities of practices.

Therefore, the main challenge posed by SEAS was to move the focus from the *construction of modules* toward the *construction of a network*, where the relationship with the discipline was still considered crucial but assume another position and required to be seen with another angle. This change of perspective required a complete de-structuring and re-structuring of a way of working, that also represents a way of thinking and our way to give accountability to researchers, teachers and the other stakeholders composing the network.

In this sense, the focus on the discipline typical of UNIBO approach to science education research needed to be enlarged and unpacked to be merged with the idea of open schooling.

To do that, we took as theoretical references the bunch of SEAS deliverables which characterize the initial milestones of the projects and that represented its conceptual foundations. In particular, we started to refer by the definition of the pool of SEAS concepts (D2.2) and the guidelines for creating open schooling networks (D2.1).

For example, in D2.2, SEAS project defined how it was interpreting the concept of 'openness' in a broad sense (D2.2) and unpack this sense into 3 dimensions. It refers to an effort to open up traditional schooling to:

a) include and reinterpret education content that is not commonly included in education, as well as scientific, disciplinary perspectives;

b) include non-traditional stakeholders in schooling and actors associated with traditional schooling to engage with actors outside of schooling;

c) connect school learning with that which is traditionally considered outside the issue of schooling.

By merging our research approach and this definition of openness, we interpreted these 3 dimensions of openness as possible dimension of action of our open schooling ideas, that are: Act at a level of content (A); Act at a level of interaction (B); Act at a level of (institutional) transformation (C). This interpretation appeared very useful because let us re-positioning our focus on the educational reconstruction of the discipline without losing our research authenticity. Moreover, this interpretation gives back a picture of our local model of open schooling which is constituted by three dimensions.

How these dimensions could be implemented in the construction of the open schooling network? Going back to the first deliverable where we set out at a project level the guidelines for creating an open schooling network, we clustered the guidelines according with these three dimensions in order to have an operative pool of challenge to take under control (Table 1.4).

Table 1.4. Correspondence between SEAS concepts and local re-interpretation.

Dimensions of *openness* within SEAS (from D2.2)	Dimensions of local open schooling model	Dimensions of implementation of open schooling network within SEAS (from D2.1)
a) **include and reinterpret education content** that is not commonly included in education, as well as scientific, disciplinary perspectives	Act at a level of "content"	• Identifying Relevant *Sustainability Challenges* (BOLOGNA-sensitive themes) • Conceiving the Collaboration as Co-Design and Joint Iterative Inquiry
b) **include non-traditional stakeholders** in schooling and actors associated with traditional schooling to engage with actors outside of schooling	Act at a level of "interaction"	• Building Upon and Dynamizing Already Existing Synergies • Identifying and Making Explicit the Diverse Needs and Competences in the Network • Establishing Shared Values and Goals
c) **connect school learning with** that which is traditionally considered **outside** the issue of schooling.	Act at a level of (institutional) "transformation"	• Working in and for Open Schooling as Transformative Innovation • Putting the School at the Centre • Creating Strategies for Impact

After finding this correspondence between our local approach and the SEAS main ideas, we elaborated on these three dimensions by identifying some features per dimensions that characterize our local model of open schooling:

Act at a level of "content" …

- The choice to refer to disciplinary content knowledge which are not only related to environmental sustainability but to extend the concept of sustainability to a broader sense and include "Bologna-sensitive themes and approaches" (e.g. future-oriented topics like climate change, quantum technologies, etc.), key criteria for identifying the themes are: *interdisciplinarity, multi-dimensionality, complexity, future-oriented, societal-relevant, transformative*.

Act at a level of "interaction" …

- The choice of elevating the trading zones as a way to trigger relationship between diverse-responsive elements of interaction: *"Each node, element, person that makes up the network has its own story, its values, its goals, an individual culture that is exchanged, enriched, and made public through connections. […] continuous exchanges, these connections between parts are part of a great collective enterprise that leads to something new, which creates a new space that cannot be traced back to the individual but is the result of the weaving of a diversity and plurality of values, objectives, and cultures."* (FEDORA model – WP1).
- The choice to use the ChangeLab methodology re-adapted within the local context.

Act at a level of (institutional) "transformation" …

- The choice Putting the school at the centre of the "model of the three spheres of transformation" and using complexity as metaphor for building schools "story of change".

4.3 Embedding the ChangeLab methodology within the local open schooling network

One of the most important challenges in coordinating and supporting open schooling for improving science education for all involves ensuring the productive and sustainable collaboration across the different partners within each network. Different institutions and groups of participants have different backgrounds and interests. Coordination and support is needed to help establish shared goals and methods. To address this challenge, SEAS chose to implement *ChangeLab Workshop Methodology* in each local network. The ChangeLab Workshops are inspired by well-established and documented intervention-based studies focusing on *expansive learning* and that emphasize the social establishment and transformation of goals and motives as the major driver for such deep learning to take place (Gutiérrez, Engeström, & Sannino, 2016). As indicated in D2.4, the SEAS ChangeLab approach is framed as intervention-based research, and more specifically as formative intervention research. The most characteristic aspect of formative interventions that SEAS took into account is that the aim is not so much descriptive as it is exploratory, and explicitly aimed at the creation of new ideas and practices. Formative interventions are thus about how things "might be" rather than on how they "are". Epistemologically, this approach takes as starting point the premise that to understand processes of social transformation—which are the type of processes one expects to find

in an open schooling innovation aimed at transforming local communities—it is necessary to facilitate such processes of change. As a general principle, within SEAS, the Change Lab methodology represents an opportunity for stimulating, experiencing, reflecting on and measuring change that the participants take ownership over.

Taking into account the three dimensions of our local open schooling network (*act at a level of content, interaction, transformation*) we interpret the spirit of the ChangeLab methodology by focusing on the choice of: i) using mediation techniques which support the interaction among diverse-responsive stakeholders (e.g. Impromptu Networking methods – Lipmanowicz & McCandless, 2014) which help to grow up together around concepts and ideas as well as distribute the accountability; ii) identifying values, principles, needs and words around which put the basis for a shared meaning about the key-concepts and fundamental themes of the project; iii) supporting multiple level of interaction within the network.

During the very first ChangeLab workshop, the network agreed about a common roadmap with the pace of the activities and a distribution of responsibilities and commitments.

Reflections of the practice of the ChangeLab workshops methodology we put into action led toward a raw model of interaction within the network which briefly consist of alternate different dynamics of collaboration and training. Briefly, it includes:

- Collective synchronised moments of reflection together with all the participants of the network about important issues (e.g. workshop for reflecting about SEAS main concepts and their definition within the local context)
- Selective operative moments of organisation with one school (e.g. meeting between a researcher and a school team)
- Cherry-picking moments of training offered to all the participants of the network attended in terms of individual aims and interests (e.g. seminar about data story-telling)
- Collective synchronised moments of training about specific and crucial issues (e.g. collective use of cCHALLENGE and other tools)
- Collective synchronised moments of synthesis and ri-elaboration of the experiences done (e.g. meeting with presentations of results by the schools).

This raw model of interaction within the network has the aim to distribute the accountability across the network and offers the chance to have multiple interaction within the different stakeholders of the network as well as to answers to different needs. Indeed, this structure with the schools at the core really worked also as a dynamic for the iterations, as a dynamic of co-construction and as a way to distribute the accountability.

4.4 ChangeLab methodology for fostering a boundary crossing dynamic

The implementation of the ChangeLab methodology functioned as a way for putting into action dynamics of boundary crossing (Akkermann et al., 2011).

Referring to the model of boundary crossing and boundary objects of Akkerman and colleagues (2011), it means to activate some crossing dynamics that let the teachers leave the comfort zone created by their proper consolidated perspective on the discipline by crossing the boundary of it and opening up toward new questions and new visions for integrating the alterity. In this specific case, the experience of the alterity means to leave certainty built in year of professionality without losing their proper expertise but trying to contaminate with the "unknown" for developing a new vision that let to "back home" with external contamination able to create new disciplinary shapes on intersection and co-construction with other disciplinary perspectives.

Beside the model of boundaries of Akkerman and colleagues, we take as a reference here also the model of interdisciplinarity developed within the Horizon 2020 project FEDORA[2] (D1.1). Indeed, within the FEDORA model of interdisciplinarity *embracing the ambiguity of interdisciplinarity* is something that redefine the role of teachers with respect to knowledge, field of competence and colleagues. The FEDORA model of interdisciplinarity suggests that the creation of interdisciplinary experience within a network imply to take care of (D1.1):

(a) Setting up ***trading zone***[3] and designing a choreography to safely guide participants to "embrace the ambiguity of interdisciplinarity". This implies brainstorming and sharing, within the network, the conditions and the principles needed to set up a *"creative and safe space where people are welcome to experiment themselves as boundary people"*. Positive emotional charge in a selected choreography is seen as a prerequisite for the sustainability of the trading zone. The spaces should also serve for coining a common language between different disciplines.

(b) Unpacking the ***skills needed to embrace ambiguity*** which implies: i) selecting and brainstorming on, within the network, a bunch of interdisciplinary attitudes and skills, ii) designing activities to foster such attitudes and develop such skills, and iii) outlining specific learning outcomes and evaluation tools to measure their achievement.

[2] FEDORA - Future-oriented Science EDucation to enhance Responsibility and engagement in the society of Acceleration and uncertainty" (GRANT AGREEMENT No. 872841, September 2020 – August 2023). PI: Olivia Levrini, University of Bologna (www.fedora-project.eu).

[3] The metaphor of a trading zone is being applied to collaborations in science and technology. Peter Galison produced the 'trading zone' metaphor in order to explain how physicists from different paradigms went about collaborating with each other and with engineers to develop particle detectors and radar. The basis of the metaphor is referred to anthropological studies of how different cultures are able to exchange goods, despite differences in language and culture.

(c) Relating interdisciplinary experiences with the mindset of creating value to society, both as an individual characteristic and a criterion for evaluation of educational institutions performance. This aspect would serve as an element boosting science teachers and educational institutions' motivation to expand the network of and for open schooling.

The reference toward these two models let to:

- Distinguish the action plans, make them clear in order to be able to intersect them without being lost in each other (at times we acted at the level of contents, at times at the level of relationships, at times at the level of the aspects of transformation of impact on the systems)

- Establish the "identities" of the participants to create areas of sharing (starting from the analysis of needs) in which the transparency of roles could give everyone their own accountability and not feel lost when "inventing" new areas, new spaces and still uninhabited to be invented and at high risk of failure (something shared by all)

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8. On the roles of SEAS tools in facilitating open schooling and scientific literacy in the context of sustainability

Author(s): Stefan Bengtsson

Keywords/tags: open schooling; tools; sustainability as teaching/learning objects; scientific literacy.

Aim & focus:
This model aims to provide guidance to reflect upon and discuss the role of SEAS tools in efforts to develop open schooling and and the democratization of inquiry processes in formal education settings. It can be used to develop open schooling by developing further and complementing existent SEAS tool

in order to address particular aspects of open schooling and the promotion of scientific literacy to address sustainability in formal education. While it aims to document the role of tools in the model, it primarily aims to outline blind spots of existing tools in relation to further "opening" of open schooling and democratizing inquiry and to suggest tools that could address these blind and weak spots.

Target audience:
Teachers, educational policymakers – sustainability policymakers – school principals – educational researchers – sustainability researchers

In the following I am to provide an outline of a model on how the SEAS tools fit into open schooling and the democratization of inquiry processes in formal education settings. This brief summary is built upon the authors engagement in tool development as well as involvement in implementing some of the tools in the Swedish network. While it aims to document the role of tools in the model, it primarily aims to outline blind spots of existing tools in relation to further "opening" of open schooling and democratizing inquiry and to suggest tools that could address these blind and weak spots.

8.1. Towards a model of the use of SEAS models

To summarize, open schooling refers to an effort to open up traditional schooling to: a) include non-traditional stakeholders in schooling and actors associated with traditional schooling to engage with actors outside of schooling; b) to include and reinterpret education content that is not commonly included in education as well as scientific, disciplinary perspectives; c) to open up learning and education (outcomes) as to contribute to and connect to that which is traditionally considered outside of concern for schooling. From this definition of the three notions of "open" in "open schooling", a set of areas of inquiry practices emerge that need to be addressed to both build up and to investigate an open schooling environment in the context of science education for sustainability. The concepts in the following sections derive from this general, initial definition of open schooling and aim to further clarify its meaning as a possible form of science education practice.

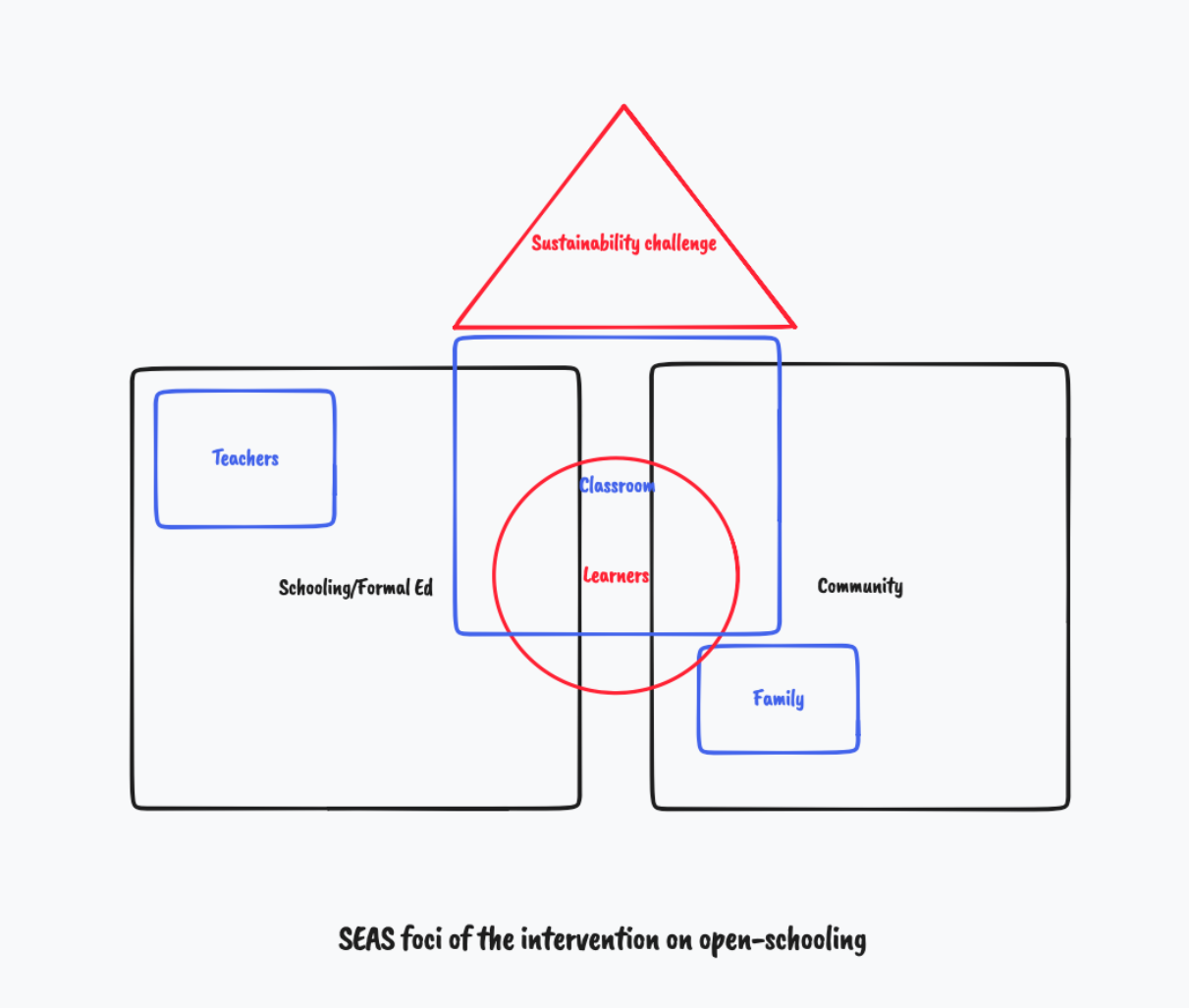


Figure 1. Overview of foci areas of the SEAS project

Figure 1 above identifies key areas of interest of the SEAS project, where the overall ambition is to open up schooling as well as to democratize inquiry. The opening up of schooling and the democratization of inquiry are closely related to another. According to the definitions of key concepts of the SEAS project (D2.2), open schooling is defined in the following fashion:

> Open schooling is thus constituted by a heterogeneous collective in which multiple institutions and organizations cooperate for science education to take place. In open schooling, learners transform themselves and their life conditions by cooperating and meaningfully engaging with the problems, expertise, and interests of others. Understanding science concepts here involves dealing with complex socio-scientific objects that have different implications for divergent participants/stakeholders, and that therefore can (and should) be approached from a "*democratizing*" and interdisciplinary perspective, always relating to personal, practical, as well as political dimensions. Schooling is democratized, and becomes a democratizing force, in at least two ways: it opens up institutionalized settings and formalized curricula to become sensitive to concerns and perspectives outside of disciplinary knowledge and education, and it engages in and contributes to a broader societal debate (Deliverable D2.2 Definitions of shared pools of concepts, p.7)

When considering the use of tools in the project and the foci of intervention as they were carried out the opening of schooling as a form of connecting heterogenous sites primarily concerned the sites of schooling in formal education and the community. While opening up entailed a process of

connecting and dissolving string barriers between sites, the democratization of inquiry related to a redirection or redistribution of influence in the relation established. To cite the definition of "democratizing inquiry" in deliverable D2.2:

> Democratizing inquiry refers hence to the inclusiveness of the process of engaging in inquiry, where inquiry is understood as relating to both giving meaning to experienced challenges/issues and finding solutions to them. To return to the quote from Dewey, "controlled or directed transformation" means that directedness is plural in democratic inquiry, as there has to be plural and incommensurable perspectives and values that shape perspectives. Democratizing inquiry entails moving back and forth between being sensitive to different directions (perspectives) and a synthesis of perspectives into a unified whole. [...] The ambition of democratizing inquiry into sustainability challenges and issues in open schooling is to allow for sensitization of learning to a) differences in understanding these issues, b) what is at stake for a diverse group of stakeholders, and c) how people are affected differently. Consequently, an inquiry into sustainability issues and challenges requires the active inclusion of wider groups of people than in normal (closed) schooling, including "*classroom*", "*families*", and the "*wider community*". (Deliverable D2.2 Definitions of shared pools of concepts, p.13)

What the tools (LORET, cCHALLENGE, and SenseMaker) allowed for was to open up boundaries and to a greater extend to connect schooling to the wider community and families. At the same time they democratized inquiry in schooling by sensitizing schooling to the difference of understanding of sustainability issues in and among families and communities. LORET and cCHALLENGE also played a crucial role in democratizing and localizing the sustainability challenge. That is, as tools, they allowed for a diversification and contextualization of sustainability challenges by relating them to the context and objectives of schooling (LORET) and the diversity of contextual experiences of these challenges in classroom, school, family and schooling (LORET and cCHALLENGE). Further, with their different foci, the key tools of LORET and cCHALLENGE were also able to expand or open up the original sites of schooling in the context of the process of democratizing inquiry and with the entry point of engaging in localized and contextualized sustainability problems. LORET was here able to connect the democratization of inquiry into sustainability challenges to curricular and policy requirements as expression of higher-level sites of influences on schooling. cCHALLENGE and SenseMaker were able to connect the democratization of inquiry to a broader social and community discourse. SenseMaker and the SEAS database that collected LORET and lesson plans generated through the LORET tool were also means of scaling and synthesizing processes of nano (individual), micro (classroom/family) and meso (school/community) changes initiated through SEAS intervention. If these tools are to be included into a model, their strength can be seen as to relate to their ability to establish topological connections between schooling and community by localizing and contextualizing sustainability challenges with regards to the grammar of schooling (institutional boundaries, requirements and objectives) as well as social and community discourse. The SEAS database and the SenseMaker tool are means to connect and collect/account for micro and nano-level changes enabled through these topological connections to meso level conditions. Hence, both the SEAS database as well as Sense Maker enable a level of aggregation or documentation of changes to emerge that can be utilized as to account for broader changes over time in relation to community and social discourse as well changes in the local grammar of schooling (institutional changes in formal schooling within the community).

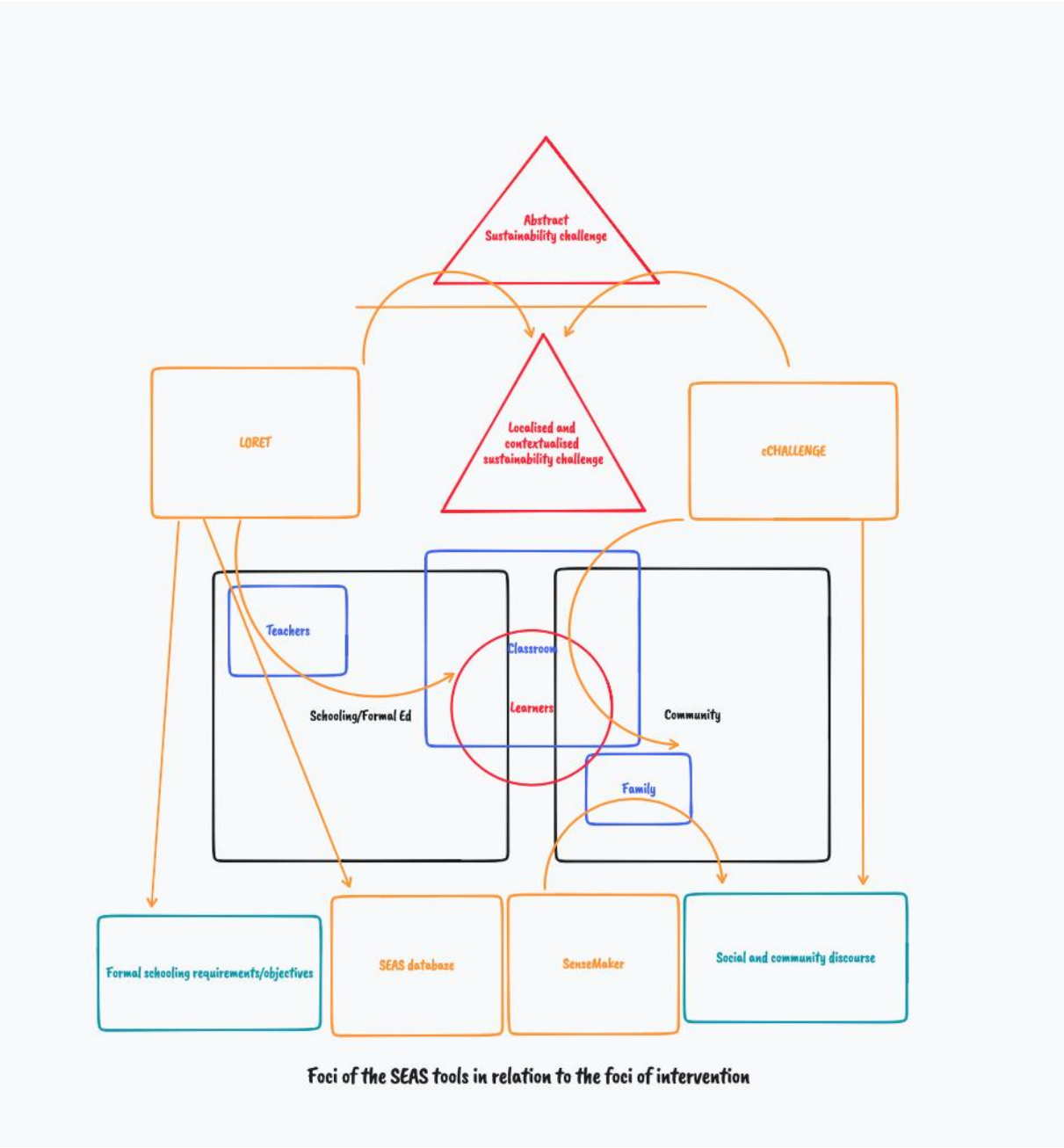


Figure 2: Account for the different foci of the SEAS tools in the opening and democratization of inquiry

8.2. Identifying blind and weak spots with regards to the SEAS objectives

In the following, we will briefly address the following potential blind and weak spots of the above outlined model of how SEAS tools can contribute to open schooling and scientific literacy in the context of sustainability: the connection to science, to community organization, the private sector and innovation.

The connection to science relates to the opening of science education in open schooling. While clearly addressing science education the existing tools do not directly enable the connection of schooling and sites where science is primarily developed, such as higher education institutions. Thus, there can be seen to be a weak spot when it comes to connecting classroom engagement with sites where primarily research is carried out and research capacity exists.

The connection to community organization relates to the institutionalization of community life as it primarily located in local governance. Such sites of governance, as in the form of municipal governance and government institutions, can be seen as influential actors to involve that might be important stakeholders to involve. Local or municipal institutions might have key insights into community interests and already identified local sustainability challenges, hence they might also be holders of resources for inquiry. Further, as many local and municipal institutions are working with implementing national policy on addressing sustainability and engage in significant financial incentives into local sustainability campaigns, they might support locally identified solutions through providing enabling conditions for their upscaling or financial support for implementation.

The connection to the private sector might be important as local private sector might be interested in supporting changes in their services/production to address sustainability or to contribute to locally relevant solutions and initiatives as enabled through open schooling activities. In addition, private sector engagement in established initiatives and activities might be means of ensuring their sustainability and upscaling once financial support that enables these activities stops.

The last potential connection to innovation relates to the objective of fostering scientific literacy. Innovation is in this context an extension of the notion of scientific literacy as the ability to engage in inquiry and to develop solutions and knowledge to sustainability challenges based on scientific outputs and methods. Innovation can be seen as to require a form of upscaling and development of solutions developed by the means of demonstrated scientific literacy. It highlights the functional and productive capability and competence of scientific literacy under the conditions of a prevalent socio-economic system.

8.3. Identifying tools for an expansion of the earlier developed SEAS tools model

Based on the above briefly outlined weak and blind spots of the existent SEAS tools, we will in this last section aim to develop an extended SEAS tools model. This extended tool model in the context of fostering scientific literacy in and through open schooling is envisioned to portray potential next developments.

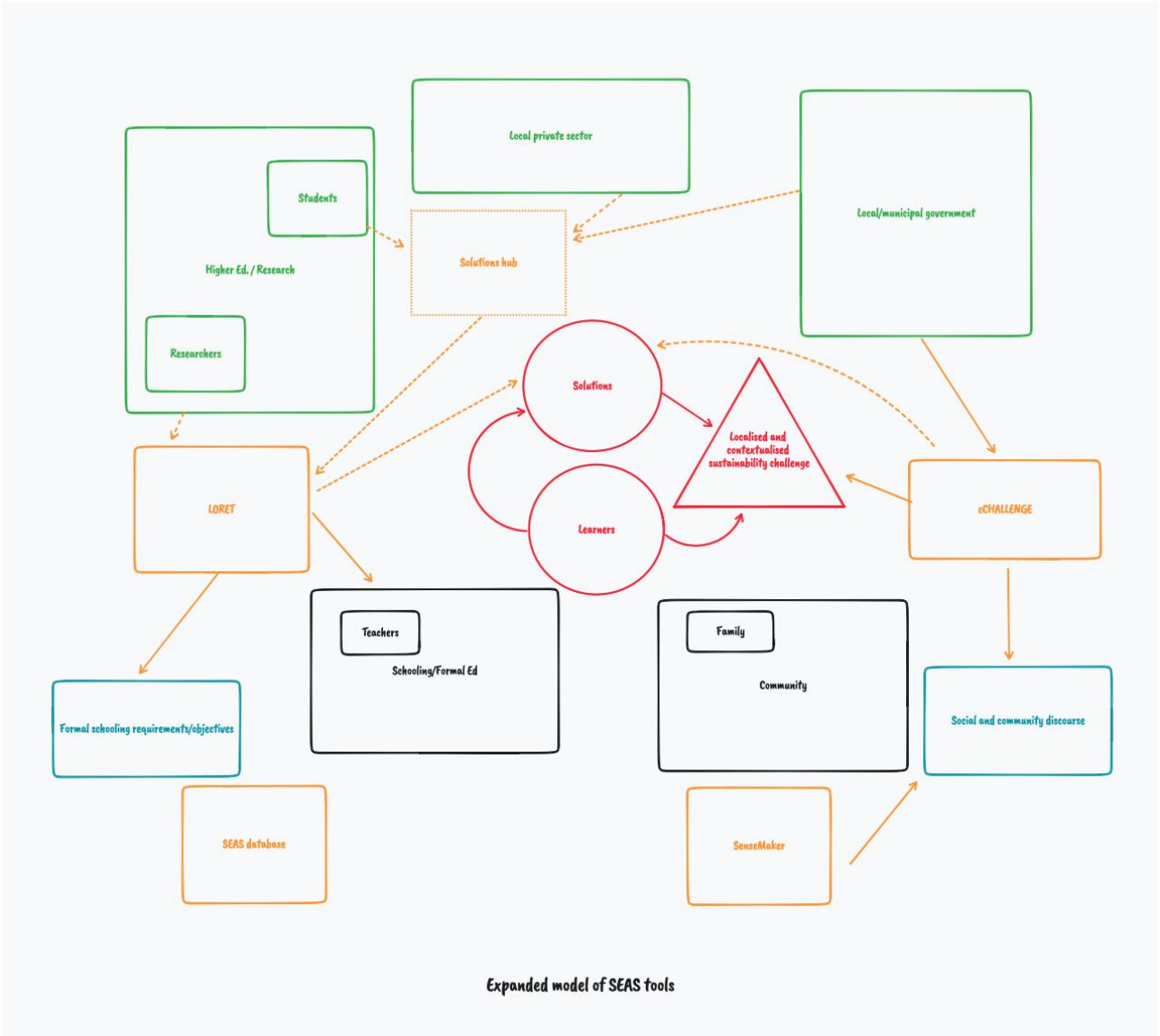


Figure 3: Expanded model of SEAS tools

Figure 3 documents an expanded model of SEAS tools. The main additional tool envisioned is the Solutions Hub. The Solutions Hub aims to connect schooling to research and higher education, the local private sector and the local/municipal government to the formal schooling processes and open schooling activities in SEAS. The connection to higher education is envisioned to connect teachers with researchers with regards to integrating expertise in research on certain locally relevant sustainability challenges in curriculum planning and content design as part of LORET plan development. Further, in relation to these researcher's courses and programmes, students as part of assignments are connected to local students work with developing solutions to localized and contextualized sustainability challenges. Students are here to offer their scientific knowledge as well as to help in the development of practical solutions. The hub would offer a) the possibility of matching students with learners in open schooling based on an initial work of students. Further, the hub would provide b) formalized structures for entering partnerships between students, learners in formal education and potentially local companies and local government. These formalized structures

are to cover legal grounds for potential commercialization of solutions (e.g. on established protocols for establishing companies and distributing copyright and ownership among solutions developers and investors). Such an innovation hub focused on the development of solutions could then be also c) be connected to local private companies and the local municipal government. Companies and local government might invest into the development of promising solutions as well as to offer expert insights into the development of solutions as interested stakeholders. Local/municipal government and private companies by open or targeted innovation funds, outlining sustainability challenges that solutions are envisioned to address.

LORET, cCHALLENGE and SenseMaker could also potentially be connected to this tool. With regards to LORET, an entry point could be to complement the inquiry processes to be facilitated by LORET with education on entrepreneurship. Educational programmes on for example young entrepreneurship could be included as an elective part of developing locally relevant solutions in LORET projects, where these programmes could focus on creating companies around solutions to be developed. Taking the outputs of LORET activities "private" might be a means to assure upscaling and further development of solutions developed as well as to strengthen learner's feeling of ownership and commitment to the solutions developed. Further, it might be helping them to make judgment on the feasibility of the solutions developed. cCHALLENGE and SenseMaker might here come as means of identifying local demands for solutions as well as to engage in marketing of developed solutions.

The addition of a potential Solutions Hub as a tool can be seen as to expand the notion of scientific literacy as to entail innovation as well as social entrepreneurship.

9. A Cultural-Historical Activity Theory Perspective on Open Schooling Innovations

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Keywords: activity systems, shared objectives, needs, motives, open schooling collaboration, cultural transformation

Aim & focus:
To clarify relevant dynamics with regards to establishing and implementing open schooling collaborations for transformation toward sustainability

Target audience:
Open schooling stakeholders across the continuum "school - society", including teachers, school leaders, and out-of-school stakeholders with an interest in such collaboration.

9.1. Introduction: Premises of a Cultural-Historical Activity Theory Approach

Pioneering works in cultural psychology (Vygotsky, 1987) and ecological anthropology (Bateson, 1972) have argued that human activity is primarily object-oriented, an idea that has been further developed and materialized in so called Cultural-Historical Activity Theory (Engeström, 1987, 2001). Underlying this approach is the premise that human activities always strive and are constituted by their striving towards meeting and fulfilling vital needs. While in most of the animal kingdom fulfilling such vital needs is accomplished through a direct relationship with the natural environment, in the case of humans, needs are both constructed and fulfilled through socio-material practices or *activities*. From this perspective, human needs or *motives* are not considered to be only biologically given but are also embedded in socio-historical contexts. Motives are in that sense inherently *bio-cultural*. They address needs anchored in our *biological* constituencies, such as the needs for food, water, safety, etc. But importantly, such needs have become cultural in that getting food, water and safety today is not so much about a question of biological fit as it is a question of social, technological and political order. Whether you drink bottled Evian water from a hotel room on top of a skyscraper, or whether you have to walk for miles to find drinkable water from a waterhole, is very much dependent on cultural and historical relationships, rather than simply biological ones. Acquiring food, shelter, or warmth are socio-material processes which unfold across layered spheres of personal, inter-personal, and institutional relationality, from the most intimate sphere of the family to the local community, to national citizenship, to the labour market, or even to the global economy. In that light, even so seemingly straightforward and mundane an undertaking as "eating" is not simply a matter of "getting food", but rather a complex process which involves cognitive, affective, social, practical, and political orientation skills.

Cultural-Historical Activity Theory uses the notion of *object-oriented activity* to theorize how different socio-material arrangements mediate the production and satisfaction of human needs or motives, relating these to specific social practices. That is, there are activities of producing and satisfying the need for food that are distinct across cultural contexts and practices (from distinct practices of food production and consumption, to the very practices of cooking and eating across diverse cultural contexts). Activities, and more specifically *activity systems*, produce both objects (or motives) of activities (what they oriented towards) as well as the means to satisfy or meet these objects or motives. Activity systems can also be understood as *communities of practice* (Lave & Wenger, 1991), where groups of individuals join in organized activities around shared objects or interests. A Cultural-Historical Activity Theory perspective on open schooling allows us to explore what forms of activity.

9.2. Understanding Learning as Activity

Learning, too, can be seen as a motive, and schools and other institutions (e.g., the family) can then be seen as activity systems that both produce and satisfy new needs of/for learning. Different schools, and more inclusively, different open schooling networks of schools collaborating with out-

of-school partners, can be seen as different activity systems, and/or can be understood as in the process of becoming a new system of activity that reconfigures and reconceptualizes what the very activity of learning is or can be. It is this ***transformative potential*** inherent in the organization of activities, and the analytical sensitivity to this embedded in Cultural-Historical Activity Theory, that makes the framework suitable for studying the establishment and implementation of open schooling networks.

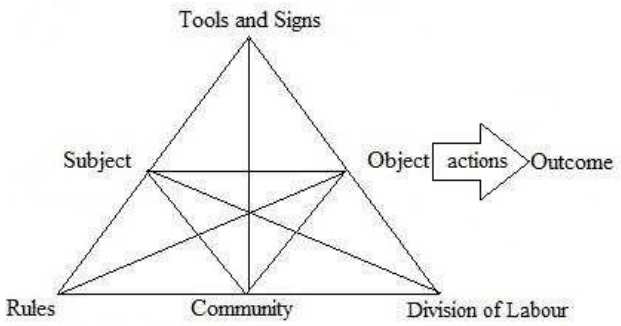


Figure 1: An Activity System (e.g., a school, or an out-of-school partner)

Activity systems can be understood as being constituted by mutually constitutive elements that, in their irreducible relation with each other, mediate the "objects" of activity. For example, let's assume that the object of activity in the activity system above (Figure 1) is "learning for sustainability" as it is mediated through particular school practices. Then for that particular activity system (that particular school), we can study the different elements and their relations as they mediate "learning for sustainability". The tools may be the sort of material devices (books, screens, online resources, timetables, tables and physical spaces) and the signs the conceptual systems (specific discourses on assessment, technical languages connected to the subject matter, the curricular goals, or the organization of the teachers' schedule). But these tools and signs do not organize learning for sustainability activities on their own. They are, in turn, mediated by the sort of community that the school constitutes, which has its own set of rules, often inscribed in the tools and signs, but also in the division of labour, which involves hierarchical structures of power (e.g., leadership structures) as well as the roles and identities taken, which in turn points us back, to another core element: the subject of activity. Here, the subject of activity means the individuals that engage in the activity, which can be understood in generalized terms (as prototypical ways of being, thinking, feeling, acting as a teacher, a learner, or a leader in that system). In more concrete, personal ways it means how learning for sustainability (in the example) is experienced from the subject's perspective.

The triangular shape and the arrows indicate non-hierarchical and dynamic relationships between those various aspects within each cluster of activity. Any aspect within the triangle is irreducibly interwoven with the whole community of practice. Each aspect informs and shapes every other. Each is informed and shaped by every other in return. Together, they constitute complexly composed

flows of (more or less) coherent activity. Think of the arrows as reciprocal movements or impulses inside larger, self-organizing dynamics.

9.3. Open Schooling through the lens of Cultural-Historical Activity Theory

Once we accept the premise that schools and other partners outside of schools can be understood as activity systems, i.e. that what makes up them is how they constitute, generate and satisfy human motives such as learning, we can then use the framework to examine how different activity systems (the school, an out of school partner), come together in joint activities where new objects are generated. More specifically, it allows us to understand open schooling innovations as deeply *transformative*.

This can be illustrated in Figure 2, where two different activity systems join around the generation of shared objects of activity. Let's assume one triangle represents a school activity system, and another one a NGO wanting to do something together with the school to problematize plastics and the local environment. For the two systems to generate a shared project, a new object of activity needs to be created. Here, it is key that establishing shared objects or motives is a *transformational* process; not in an abstract way, but in a very concrete, socio-material way. Because new objects of activity cannot be created without the consequent generation of new relationships between tools, signs, rules, community, division of labour, and of the very subjectivities (i.e., ways of being and experiencing) that constitute the community of practice or system of activity.

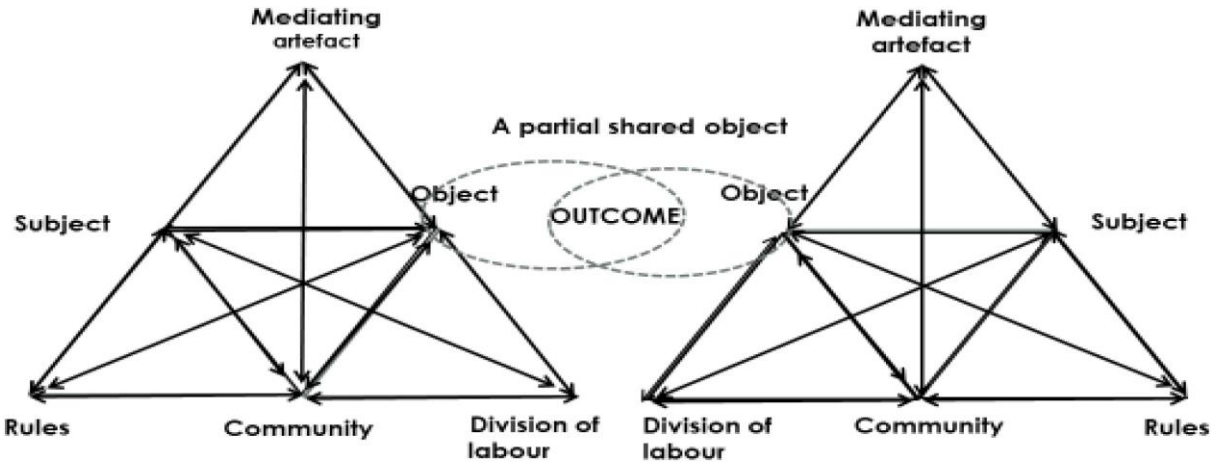


Figure 2. "Activity Systems" according to Cultural-Historical Activity Theory

In the SEAS project, we have documented and explored the relevance of *identifying, articulating, problematizing, and negotiating* ***shared objects*** *across the continuum between the school community and out-of-school partners*. Open schooling networks create novel activity systems that transform both teachers' and learner's identities as subjects, the rules, values, and principles that organize these new activity systems, as well as the material tools that allow for the articulation of the new forms of producing and satisfying needs for education for sustainability. They do the same for every actor involved, so that transformation concerns not just schools, but the broader community at large:

open schooling can become transformative across institutional borders. Science centres, industry partners, and other stakeholders outside of the school, by taking part in the generation of common goals for learning and acting towards sustainability, develop new ways of understanding their goal as environmental actors, and as (informal) educational actors. These broad processes of learning that go beyond the individuals' acquisition of given learning contents, but which involve expanding one's personal, interpersonal, and institutional boundaries through the transformation of their system of activities, is referred to as *expansive learning* (Engeström, 2001).

9.4. A few examples of expansive learning through open schooling

Throughout the three years of the SEAS project implementation, we have been able to document numerous processes of expansive learning in which open schooling has led to new activity configurations, and to new views and practices on the role of schools and other actors around the school in educating for sustainability. Several of these examples are documented through the project's Annual Local Assessment reports (D3.1 and D3.2), accessible at www.seas.uio.no. Other empirical cases are being reported in research articles under development. Here, we cite a few examples for illustrative purposes, where we exemplify the usefulness of the framework for the analysis and evaluation of the transformative potential of establishing and scaling up open schooling collaborations.

One insight we have gained is the realization of the importance of considering distinct overall approaches to the task of establishing shared objects of activity and the opportunities these bring for enacting transformation towards more or less engaging and meaningful forms of teaching and learning. In this regard, we have observed both instrumental approaches, as opposed to more intrinsic approaches to the task of establishing shared goals. In instrumental approaches, the partners in the collaboration orient towards specific goals and objectives of their own, without necessarily crossing boundaries and generating deeper shared objectives—the latter remaining at an instrumental level in which they serve as a proxy to achieve other internal goals. In one case, for example, an urban design company needed students to take part in participatory design processes as part of their own goals to fulfil design requirements, whereas the schoolteachers involved were concerned on "what was in it" for the learners and their competence goals. Such instrumental collaborations have tended to remain at a more superficial level and, while also opening for more expansive processes of learning and development in the participants, they are limited in the reach of the transformations. As a contrast, we have documented intrinsic approaches in which the collaboration and negotiation of shared goals has been much more explicitly oriented towards the why and the what of the collaboration, with the partners establishing goals broader than any of those characterizing the respective partners' points of departure. In these cases, transformational processes have been deeper, reaching further degrees of socio-material reconfiguration.

The sort of expansive learning that we have documented concerns all layers of activity, from reconfigurations of the division of labour within and across institutions, to the redefinition of learners'

and teachers' identities, their understanding of the teaching and learning subjects, and of what the whole purpose (object) of the educational endeavour is. We have documented cases in which experienced challenges of collaboration, including lack of resources and time, have been overcome by reconfiguring division of labour, both within the school organizational structures (what roles and rules organize collaboration between school leaders and teachers, for example) and between the school and the out-of-school stakeholders (how external partners may relief rather than increase the workload of teachers/schools by taking educational and pragmatic roles in the collaboration). We have also seen that, while there are different organizational approaches to managing the collaboration (e.g., coordination of activities being led by school leaders vs. teachers being the leading voice and coordinating agents), there is no one right or wrong approach. Different divisions of labour work differently depending on the type of tools, rules, community and goals of the specific activity systems.

When successful collaborations are established—successful from the point of view of open schooling as an innovation that provides with transformative learning opportunities that bring about community well-being—the most relevant outcomes tend to be at the level of how the very object of activity of the collaboration is conceived and approached, and how this leads to changes in the subjects. This may involve smaller as well as broader conceptualizations, which in turn have expansive consequences across the activity systems' elements. In one of the collaborating schools, for example, a history teacher and a science teacher collaborated for the first time in co-creating, together with researchers, a unit on oil industry and sustainability in Norway. At the outset of the collaboration, the history teacher had no particular interest or goals connected to questions of sustainability because his subject, he believed, was less relevant for the issue. Sustainability, in his view, was a natural sciences problem. Through the collaboration with researchers, and later on with academics and activists connected to environmentalism and oil industry in Norway, this teachers' view on the importance of understanding the socio-historical causes of the current climate crisis radically changed, changing his views of his role as a history teacher in educating for sustainability. The same transformation was observed in the natural science teacher, who felt at the outset that she was not so well versed and relevant when it comes to connecting the natural sciences questions to sociopolitical dimensions of teaching. Through the unit, though, she did establish biographical connections with the topic and her own master studies several decades ago in Sri Lanka, where she had been an ecology student investigating monocultural practices of cane sugar agriculture and its ecological impact. These and other examples illustrate the deeper, expansive transformative potential of open schooling, and the usefulness of a cultural-historical activity theory approach to these.

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