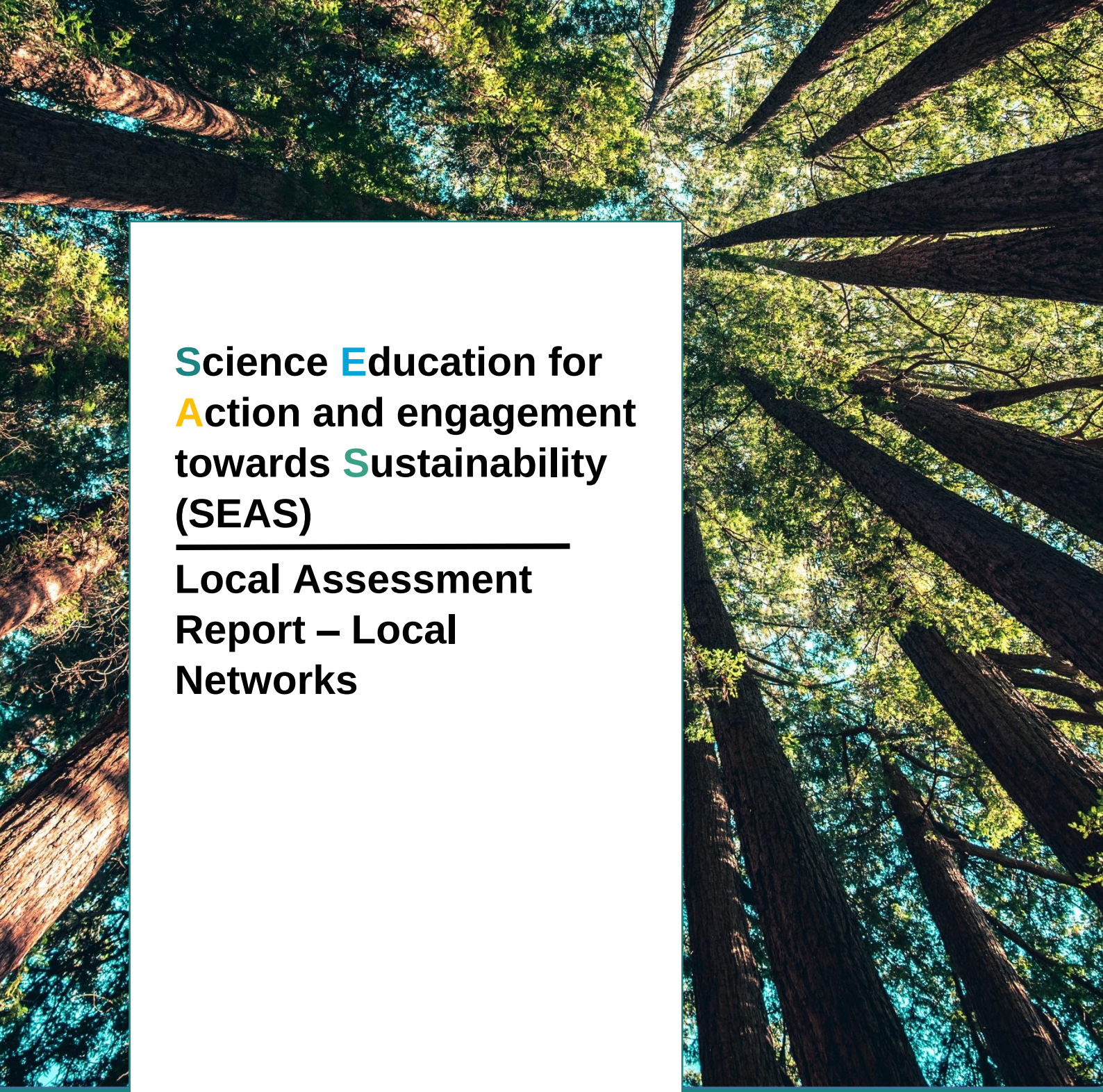

Science Education for Action and engagement towards Sustainability (SEAS)

Local Assessment Report – Local Networks

D3.2

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Contents

1. Introduction to local assessment reporting

The aim of this document is to collect local assessment insights from each local network that will (a) inform the adjustment and/or further development of the project's concepts, tools, and methods (see below) at both the local level and the project levels, and (b) inform the development of general models related to open schooling, as elaborated in the project description. More specifically, the local assessment report is aimed at documenting challenges and opportunities with respect to three main areas of interest to open schooling. These areas correspond with three of the four main deliverables to be produced as part of WP5 and the project's assessment framework. The three areas are:

- Local assessment area 1: Establishment and implementation of open schooling partnerships
- Local assessment area 2: Transformational engagement, scientific literacies, and motivation
- Local assessment area 3: Teaching scientific literacy

The fourth deliverable to be developed as outcome of WP5, an assessment framework document, can be synthesized from the reporting produced for each of the three areas identified above, where not only challenges and opportunities of relevance to local implementation, but also more general insights about concepts, tools and methods is reported and later integrated. It is therefore that this fourth deliverable does not find a specific local assessment area counterpart.

Global Assessement Deliverables and their correspondence with the local assessement reporting areas
• Report on models for the establishment and implementation of open schooling partnerships (D5.2) → Local assessment area 1. • Report on models on transformational engagement scientific literacies and motivation (D5.3) → Local assessment area 2. • Report on models of teaching and learning scientific literacy (D5.4) → Local assessment area 3.

Table 1. Findings reported to each area in the local assessment shall inform the development of global assessment deliverables.

Reporting area 1: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface.

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. The Local Assessment report shall provide insights on the challenges and opportunities that have emerged at the interface of the school and the out-of-school contexts.

Data sources to be considered include, but are not limited to: preparation and follow up meetings/workshops/interviews involving researchers and school leaders/teachers; between researchers and out-of-school actors in the network; between school leaders/teachers and out-of-school actors; participation of family members, etc.

Analytical concerns to be considered include, but are not limited to: co-design processes, change-lab workshops, institutional boundary crossing or lack thereof, practical/pragmatic coordination issues within and across institutions, access to data sources, …

Reporting area 2: Challenges and opportunities to transformational engagement, scientific literacies, and motivation.

One of the main premises in the SEAS project concerns the idea that, in order to address the important challenges of sustainability that we are facing, education needs to revise the ways in which scientific knowledge is understood and delivered in education, so as to become actionable and meaningful in real life contexts. As elaborated in the SEAS project description, a long tradition of socioscientific issues in education has shown how, when students engage in addressing real, complex problems, knowledge on scientific issues needs to be expanded so as to include personal as well as political dimensions. Local assessment in this area aims to document the forms of scientific literacies that emerge (factually or potentially) through open schooling collaboration, and how these relate to the participants' motivation for and agency towards knowledgeably addressing real life problems of sustainability. It also involves possible assessments on ways in which open schooling innovations present new or particular challenges to more traditional forms of teaching.

Data sources to be considered include but are not limited to questionnaire (including SEAS Global Assessment Instrument, GAI), interviews, and ethnographic observations of learning trajectories across contexts.

Reporting area 3: Challenges and opportunities to teaching scientific literacy

Just as new or particular forms of interdisciplinary science learning for action and engagement towards sustainability are expected in open schooling innovations, new challenges and opportunities to teaching in these types of innovative settings are expected too. In this section, local networks are expected to provide with assessments on progress, challenges and opportunities documented in this regard. Particular emphasis is made to teaching strategies in the classroom, outside of the classroom, as well as on the collaborative challenges and opportunities that emerge in the collegial relationships, both within teachers and across teachers and school leaders.

Data sources relevant to this area include but are not limited to classroom and field (out-of-school) observations of teaching work, teacher planning meetings and meetings involving teachers and

teacher leaders, as well as co-design workshops including teachers and focusing on teaching strategies or tasks.

Common sections across reporting areas

For each area to be documented, local networks are required to specify the methods (data sources and analytical procedure) and the findings of relevance to the given area as well as the models that will be (further) developed in view of contributing to *D5.2 Report on models for the establishment and implementation of open schooling partnerships, including tools, methods and resources facilitating science education for sustainability citizenship*, *D5.3 Report on models on transformational engagement scientific literacies and motivation*, and *D5.4 Report on models of teaching and learning scientific literacy for sustainability by open schooling partnerships*[1]. Findings for each area of interest are to be further elaborated with respect to the following:

- Findings are to be elaborated with respect to their implications with regards to the SEAS and other emerging concepts, tools, and methods used in the local network, with special attention as to whether and how updates/adjustments stemming from insights gained during year 1 have been taken up and had (or not) an impact during year 2. Table 2 presents SEAS initial concepts, tools, and methods.
- As part of the section elaborating on implications for SEAS tools, concepts, and methods, a reflection is requested as to whether and how differences in gender, students' backgrounds, and or geographical variation have (or not) informed the use and development of concepts, tools, and methods in the local network.
- students' backgrounds, as well as geographical variation
- For each area reported, local networks are also requested to summarize their findings in the form of a conceptual model including core concepts/elements and their relations as observed through your assessments.
- In order to position the findings and model in the existing literature, an additional subsection requests the local networks to elaborate on how their findings and model contribute informing existing debates or *dilemmas* in the field(s) relevant to open schooling for sustainability.

[1] Here, the local networks can choose to either use existing models and apply them to their assessments in order to further develop them, or to create new models (inductively) based on their analyses. Each network is expected to contribute with at least 1 model to each of the 3 deliverables.

SEAS CONCEPTS	SEAS METHODS	SEAS DIGITAL TOOLS
• Conceiving *scientific literacy* as/for *transformational action*... • ... acting upon *three spheres of transformation* to generate opportunities for *expansive learning*... • ... and recognising the centrality of *narratives for change.*	• Implementing a design-based, research-practice partnership approach... • ...through an iterative implementation-assessment process... • ...and stimulating collaboration and participation through *ChangeLab Methodology*.	• cCHALLENGE tool to support addressing sustainability challenges • SenseMaker as a tool to monitor learning and narratives of change • LORET supports educators generating locally relevant teaching resources

Table 2. SEAS initial concepts, methods, and tools are to be reflected upon and

The following sections provide further guidance with resepct to the reporting elements that are specific to this second annual local assessment, including an additional overall section on COVID-19 impacts.

Elements specific to the second annual local assessment

In its general structure (reported above), the SEAS second annual local assessment is analogous to the first local assessment report (Deliverable D3.1), completed in December 2020. This is so because the three core areas reported in the first annual local assessment remain central to the goals and foci of the SEAS project. By continuing to focus on these three areas, there emerges the possibility to build upon prior findings (or lack thereof) reported in the first local assessment, providing opportunities to extend and/or contest those initial findings.

However, the current second annual local assessment (Deliverable D3.2) includes a number of elements that extend (mapping local dilemmas, covid impacts and implications) or modify (reporting on updated tools, concepts and methods and to what extent they have or could differentiate across gender and specific educational needs) the three main reporting areas. The first element involves a modification of the request on SEAS concepts, tools and methods, where specific emphasis is required as to whether and how updates and modifications have been deployed with respect to the SEAS concepts, tools, and methods used in the first iterations, and the consequences and/or impacts these modifications/updates have had, with renewed focus on diversity/differentiation issues. The second element involves an additional section under each area in which each local network is requested to reflect upon generative knowledge dilemmas that their findings represent or can contribute to.

Further clarification as to updates performed and experiences gained through deployment of updated open schooling tools, concepts and methods, and differentation.

For each area, local networks are requested to report findings on the open schooling concepts, tools, and methods that have been used and/or developed in their local networks findings, and how these findings may inform further developments both at the global (project and research field) and

the local network levels. As part of this section, local networks are requested to address the following questions:

- What are SEAS/open schooling concepts, tools and/or methods that have emerged or been taken up in your local network during this second implementation year?
- What are adjustments or updates that have been implemented with respect to concepts, tools and/or methods used/emerging during the first implementation year? Were these changes/adjustments/updates made on the basis of prior local assessments and how?
- Have you observed differential impact or consequences with respect to the participants' gender, background or geographical variation? Have there been challenges or recognized opportunities with regards to adjusting the different concepts, tools and methods to different gender, background, or geographical variation?
- How do your findings in this second local assessment inform the further development and adjustment of the SEAS tools, concepts and methods?

From local assessment to global synthesis: summarizing findings in the form of conceptual models, and identifying knowledge dilemmas in open schooling.

Reporting through Conceptual Models

SEAS aims to create practically useful knowledge in three important 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 is our shared 'object of knowledge' and the global synthesis is to bring together insights and knowledge created through the local assessment with the aim to progress knowledge in these three areas. More specifically, we will do so with a focus on the 'SEAS concepts and tools' as described in D2.2. However, this shared 'object of knowledge' is addressed from a variety of perspectives in the different local networks. Not only do we focus on diverse 'objects of study' (very different practices/experiments across the local networks), we also use divergent theoretical approaches and analytical methods. SEAS' aim is to use this rich (empirical, methodological and theoretical) diversity as a strength. This means that we need to design an approach to co-construct the envisioned deliverables D5.2, D5.3 and D5.4 that allows to, on the one hand, do justice to the local diversity and, on the other hand, make sure that each of these diverse contributions is relevant and helpful to realise our joint goal, that is, to create knowledge on our shared object of knowledge (SEAS concepts and tools related to the three areas).

As a means to synthesize findings across local networks while also preserving the diversity of analytical frameworks and approaches in the different networks, each local network needs to summarize their findings, gained through local assessments 1 and 2, in the form of conceptual models (one for each of the three reporting areas) that will contribute to progressing knowledge on open schooling and the challenges and opportunities it entails for the development of the sort of

scientific literacies and transformative learning that are called upon in education for sustainability. This way of working allows us to preserve the diversity of analytical methods and theoretical approaches while also building on common ground and towards an accumulation of relevant knowledge and experiences under shared matters of concern to educators, learners, and citizens at large. This diversity of models will be later assembled in the WP5 deliverables mentioned above.

In order to build a model from your findings, there are a number of options (as explained and illustrated in the PMT meeting of 12 May 2021). You can use existing models (e.g. some of the ones presented during the PMT meeting on the topic or other available models) that are relevant in relation to open schooling and for SEAS' concepts and tools for making sense of the local assessment findings. In this case, the local assessment is used to further develop the model, for example by identifying their strengths and potential pitfalls, by exemplifying how they can be applied in an open schooling context, etc. (always related to our shared focus on SEAS' concepts and tools). Another option is to inductively create new models out of your empirical findings. In any case, the idea is that each local network contributes with 'ready-made' building blocks (in contrast to fragmented, partial findings) that can be assembled in the WP5 deliverables. Combinations of these two approaches may also be followed (building on but significantly modifying existing models as a result of inductive insights). As a whole, these models need to cover all SEAS' concepts, tools and methods, as well as those concepts, tools and methods that may have emerged locally as part of the open schooling activities.

Mapping Dilemmas in Open Schooling: Building an Atlas

In addition to providing conceptual models, local networks are requested to identify, for each reporing area, how their findings and/or conceptual models contribute to scholarly debates on given dilemmas characterizing the field of open schooling for sustainability (which includes research fields such as sustainability education or science education among others). Mapping how the different insights gained in different networks about common concepts, tools and methods contributes to existing and/or emerging dilemmas allows us to map the field of open schooling as a vibrant field of emerging practices and matters of concern that can orient researchers and practitioners, rather than presenting the field as consisting of more or less settled facts that can be applied across contexts/countries. Open schooling, and education towards sustainability more broadly, are developing fields that require ways of questioning and of critically thinking rather than given scrips or answers, and our focus on a rich diversity of models reflects this. The assemblage of our diverse models should provide educators, policymakers, researchers, etc. with a navigational tool—an atlas of dilemmas—that helps them reflect, discuss and develop their own responses and approaches to challenges of sustainability through education. This navigational tool will not be one singular 'map' but rather an 'atlas' that allows to address the topic from a diversity of perspectives.

Reporting on COVID-19 pandemic impacts and lessons

The COVID-19 global pandemic has been one of the most defining circumstances of the reporting period. Although in the prior annual local assessment report references to the pandemic were made,

this was not explicitly requested. For this second reporting period, each local network is requested to reflect upon the ways in which the COVID-19 pandemic has affected the network's activities and outcomes, and what learning lessons can be drawn from the entire project period in this respect.

2. Austria local assessment

Reporting area 1, Austria: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface.

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. The Local Assessment report shall provide insights on the challenges and opportunities that have emerged at the interface of the school and the out-of-school contexts.

Data sources to be considered include, but are not limited to: preparation and follow up meetings/workshops/interviews involving researchers and school leaders/teachers; between researchers and out-of-school actors in the network; between school leaders/teachers and out-of-school actors; participation of family members, etc.

Analytical concerns to be considered include, but are not limited to: co-design processes, change-lab workshops, institutional boundary crossing or lack thereof, practical/pragmatic coordination issues within and across institutions, access to data sources.

Methods

Data sources and Participants

1. In order to illustrate the Austrian local network activities, first, we briefly give insight and critically discuss collaborative practice within the Austrian local network in terms of chances and challenges of collaboration. This discussion bases on own reflection of the Austrian local network team (N = 7).

2. A workshop at the *1st Global Transdisciplinary Conference of the Donau University Krems*, the 27th of September 2021, called "From transdisciplinary research to transdisciplinary education – How can transdisciplinarity in formal education succeed?", which was organized and moderated by the Austrian local network team, reveals chances and challenges of collaboration in open schooling in general and within the Austrian local network. Beside scientists of the field of education (N = 5), students (N = 20), aged between 14-17 years, teachers (N = 4) as well as the head of one school took part at the workshop. The students and teachers who took part belong

to the Austrian local network and gave insight into their perspective of the collaborative practice within the network and further open schooling experience. Students and teachers were from different school types, Austrian and Bavarian secondary schools, federal colleges as well as from a Montessori school.

3. In addition, data was collected by means of a standardized questionnaire for N = 29 students, aged between 16-18 years, and N = 3 teachers of an Austrian federal college, which is part of the Austrian local network. The data was collected at the end of the only one Alpine Research Week (one of the transdisciplinary modules in the Austrian local network) which could take place in September 2021.

4. Additionnally, the findings of structured interviews which were done in September 2020 at the end of an Alpine Research Week, are discussed in this section. The structured interviews were performed with N = 16 students, aged between 16-18 years, and N = 2 teachers of an Austrian federal college. Preliminary findings of these interviews were already discussed in the first local assessment report.

Please note, preliminary findings of the Global Assessement Instrument will be discussed in the next section.

Analytical procedure and approach

The structure of the Austrian local network and the collaborative practice will be illustrated by means of a graphic and discussed by means of own reflection of the Austrian local network team.

- The workshop at the *1st Global Transdisciplinary Conference* was a transdisciplinary discussion on eye level between scientists, teachers and students, the latter part of the Austrian local network. The participants discussed in two small groups about chances and challenges of transdisciplinary collaboration in general and about their experience of the collaborative practice in the Austrian local network. In more detail, they discussed about their experience of todays formal education, with a focus on the secondary school context, and about the contribution of today's education to the achievenment of the demands of Education for Sustainable Development (UNESCO, 2021a) and Agenda 2030, especially here to name, Sustainable Development Goal 4, Quality Education (UNESCO, 2021b). Moreover, it was discussed how transdisciplinary collaboration between schools and out-of-school partners can contribute to fulfil these demands and which barriers, system specific and barriers at a personal level, exist in regard to implementing transdisciplinary collaboration in today's formal education. The questions were developed in advance by the Austrian local network team to stimulate discussion, however, the participants were also free in introducing questions they are interested in. At the end of the group discussions, the participants were asked to note the most important findings of the workshop in a online tool. At the end of the workshop these findings and the findings which were noted by the secretaries (one secretary per group) were presented in the plenum by the moderators of the group

discussion. The findings of the workshop which are presented in section "1.4 Findings" are not evaluated yet, hence they base on preliminary results.

- The standardized questionnaire, which was handed over to teachers and students at the end of the Alpine Research Week in 2021 was descriptively analyzed by IBM Statistics 26. The questions for the teachers base on a Likert Scale (0 "I do not agree at all" to 5 "I fully agree"). The questions for the students base on a Likert Scale (1 "I do not agree at all" to 6 "I fully agree"). By means of the questionnaire teachers and students were asked about their experience and the outcomes of the collaboration with scientists of the collaborative practice within the Austrian local network. Please note, that the findings base on a self-evaluation of students and teachers.

- The semi-structured interviewed which were performed at the end of the Alpine Reserarch Week in 2020 were transcribed and evaluated by the program MAXQDA 2020 by means of a content analysis according to Mayring (2014). In a first evaluation phase, the categories were inductively derived from literature about transdisciplinarity and in a second phase expanded by means of an inductive deduction from the data. By means of the semi-structured interviews students and teachers were asked about their experience and the outcome of the transdisciplinary collaboration with scientists. Moreover, teachers were asked about their organizational effort and the added value of the collaboration with scientists in the Austrian local network.

Findings

First we give an insight into the Austrian local network activities and the modular structure of the conceptual model and collaborative practice within the network. The Austrian local network is a collaboration between the Austrian local network team (scientists in the field of geographic education) of the University of Innsbruck and teachers and students of Austrian and Bavarian schools, as well as scientific experts of different fields. The collaboration already started before the SEAS project in 2012 between the working group *Education and Communication for Sustainable Development* and one secondary school in Bavaria. The head of the school and one geography professor of the working group jointly initiated the collaboration. Since the foundation, the network has grown continuously with more than 3500 students and 100 scientific experts having been part. During the SEAS project, the network came along with one further school in the first year and three further schools in the second year. The collaboration mainly starts with the invitation for teachers to tender a teacher training. The Austrian local network team sends emails with the invitiation to various Austrian and Bavarian schools and calls the secretaries of the schools to promote the training. During the teacher training the teachers get to know the learning modules within the Austrian local network and the underlying didactical approach which bases on a moderate constructivist understanding of learning (Riemeier 2007) and inquiry-based learning (Pedaste et al. 2015), embedded in a inter- and transdisciplinary approach (Lang et al. 2012). After the teacher training, which takes part once a year,

partly the teachers themselves contact the Austrian local network team or the other way round. Once starting the collaboration, teachers, students and the Austrian local network team meet for the kick-off event (see Figure 1).

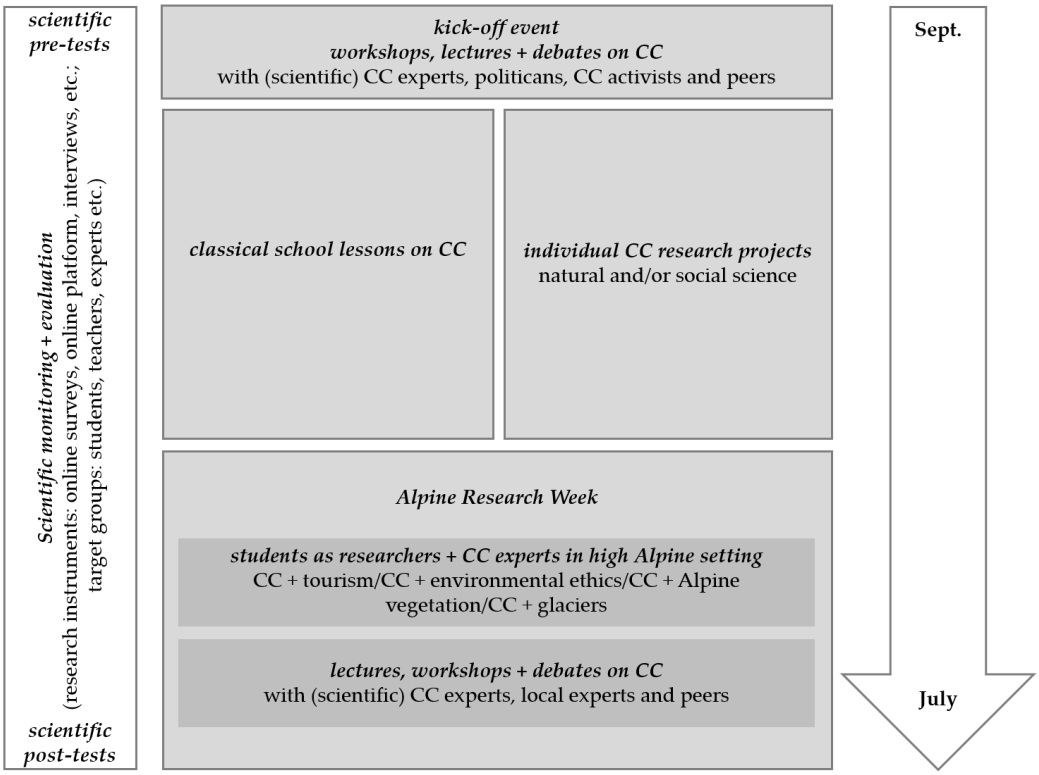

Fig. 1. The modular structure of the Austrian local network (source: (Kubisch et al. 2021))

During the kick-off event students discuss with scientific experts, politicians, activists and peers about the topic of climate change on an eye level. Politicians and scientific experts are invited by the Austrian local network team and take part voluntarily. The voluntary nature of the participation particularly presents a challenge for the collaboration of politicians and scientific experts, since there participation is not remunerated and they have to collaborate within there working time or to take a free day. The same is true for the participation of scientific experts in the Alpine Research Week, were they normaly support the local network for two up to five days. The overnight stay and journey of scientific experts at the Alpine Research Week is paid by the respective school. However, so far, the Austrian local network team always has acquired motivated scientific experts who supported the network voluntarily. Nevertheless, the acquisition is sometimes time consuming, having to contact various scientific experts, search for new ones and aligning the dates between teachers, scientific experts and the team.

After the kick-off event, students have classical school lessons on climate change in cross-cutting subjects and students develop individual climate-related research projects. These two modules are guided by the teachers themselves. Having taken part at the teacher training, the aim is that the teachers run the two modules based on the didactical approach proposed in the teacher training, namely inquiry-based learning (Pedaste et al. 2015) and a moderate constructivist understanding of

learning (Riemeier 2007) embedded in an inter- and transdisciplinary approach (Lang et al. 2012). Being in continuous contact with the teachers, we consider as one challenge, that the teachers who participated at the teacher training, also convince teachers of other subjects, who did not take part at the teacher training, to focus on climate change and to grant time for the individual projects. The Alpine Research Week builds the end of the collaboration within the Austrian local network and is at the same time linked with the highest organizational effort beside the kick-off event, since the Austrian local network team needs to align the date of the Alpine Research Week with the teachers and experts. Particularly, in the Covid-19 situation this resulted as very difficult, due to a continous change of regulation and uncertainty. Moreover, the team needs to book the overnight stays for the team and acquire the scientific experts. During the Alpine Research Week, the students do research on climate change with scientific experts in different fields (e.g. tourism, environmental ethics, glacier retreat, vegetation, soil or nutrition). Moreover, at the end of the Alpine Research Week, the Austrian local network team organizes local experts from different fields, who answer students' still open questions. Concluding with our own reflections on the collaborative practice within the Austrian local network, from our part, the collaboration is linked with a high organizational effort, continuously being in contact with teachers and scientific experts.

The learning effect of the didactical approach of the Austrian local network is continuously monitored by means of an online standardized questionnaire before and after the collaboration (herein called general local assessment instrument).

2. Basing on experience in different open schooling initiatives, including the Austrian local network, the preliminary findings of the transdisciplinary workshop reveal that especially teachers have the opinion that the present formal educational system which mainly bases on formally determined knowledge transfer is not on time. The head of one school mentioned for example that education and practice have to be combined and that hierarchies have to be dismantled, transferring more power and responsibility to the students by means of participation. Both students and teachers mentioned the higher learning effect and importance of open-schooling, giving students the possibility to work with out-of-school partners on real-world problems. However, both teachers and students also mentioned the challenges of implementing open schooling. The formal educational system with predefined school curricula, which mainly bases on knowledge transfer, not on competence development, and the inflexiblity in time and extra personal resources was mentioned, which is required by transdisciplinary collaboration. According to the teachers, these barriers are difficult to overcome, if transdisciplinary collaboration should be integrated in the existing system. Both teachers and scientists claimed for a opening of the existing educational system, leaving space for transdisciplinary collaboration between students, teachers and out-of-school partners. At the moment transdisciplinary collaboration is considered by both students and teachers as "add on" to the "normal" teaching practice, which has to be done after school, meaning an extra workload for all persons involved. However, the teachers and scientist also mentioned that there already exist new school formats which transgress school and discipline boundaries or progressive modules – like project seminars – and voluntary subjects at some schools, which leave space for transdisciplinary collaboration. Students mentioned that the latter are sometimes difficult for them to join, since they

are already overworked by the obligatory subjects and need to fulfil the learning objectives in order to achieve their school-leaving qualification. Additionally, teachers also mentioned that the openness towards transdisciplinary collaboration also depends on the willingness of the teachers themselves, the support by the collegium and the head of school. The lack of willingness of the teachers themselves, their collegues or of the head of school in regard to experimenting with new open schooling formats, often constitutes a barrier to transdisciplinary collaboration. Another challenge named by the students was that they did not feel taken in serious by out-of-school partners and that they feel sometimes personally challenged by the additional workload and the responsibility they have, working with out-of-school partners. Both teachers and students mentioned, that their vision for a change in the educational system would be a mixture of the educational system how it exists nowadays and the opportunity to work with out-of-school partners on real-world problems. In respect to the mentioned need for change in the educational system, the head of the school considers the Covid-19 crisis as a chance, teachers had to be more flexible and experiment with new learning formats and students had to take more responsibility for their learning process. The latter is one of the prerequisits for open schooling as mentioned by the head of the school.

Focussing on the Austrian local network both teachers and students mentioned the collaboration with scientist as a valuable experience, since the collaboration has supported to broaden their minds in regard to the significance and urgency of climate change and environmental issues in general. Moreover, the students mentioned that the collaboration raised their awareness about environmental problems which is an important step towards fulfilling the sustainable development goals according to the students' opinion. Additionally, the teachers mentioned, that the modules of the Austrian local network were easy to integrate into everyday teaching activities since they have the opportunity to have a project seminar in school.

3. Focussing on the standardized questionnaire which was handed out at the end of the Alpine Research Week in September 2021, the teachers (N = 3) indicated to like the cooperation with the students within the Alpine Research Week (Mean Value (MV) = 4.67) and that they learnt a lot about their students (MV = 5.00). Moreover, teachers liked the cooperation with scientists (MV = 4.67) and learnt a lot of them during cooperation (MV = 4.67), especially facts, they did not know before (MV = 4.33). Additionally, the teachers indicated that they wish to cooperate more often with scientists in school (MV = 5.00). The standardized questionnaire of the teachers bases on a 5-Likert Scale (1 = "I do not agree at all" to 5 = "I fully agree"). The findings in respect to students' experience with the cooperation with scientists and teachers within the Alpine Research Weeks shows, that students liked the cooperation with scientists (MV = 4.21), that they learnt a lot by cooperating with scientists (MV = 3.93), especially about contents, they did not know before (MV = 4.34). Most of the students wish to cooperate more often with scientists in school (MV = 3.55). Since inquiry-based learning on real-world problems is one of the didactical approaches of the Austrian local network which is embedded in a transdisciplinary collaboration, the students were additionally asked about their experience of inquiry-based learning. The students liked to do research on real-world problems within the Alpine Research Week (MV = 4.71), and liked to do research on their own questions (MV = 4.07). Moreover, students wish to work more often in school on real-world problems (MV = 4.39) and would like also

to have the possibility to have class outside the classroom (MV = 4.54) and especially in nature (MV = 4.46).

4. Analyzing the results of the semi-structured interviews after the Alpine Research Week in 2020 by means of a qualitative content analysis, the opportunities of the collaboration within the Austrian local network can be pointed out. In total, structured interviews were performed at the end of the week with N = 16 students and N = 2 teachers. The codings refer to the number of answers in the respective category by students and teachers. Please notice, that also more than one coding can be refered to one person. The codings of students and teachers reveal an increase of awareness (11 codings) and a mutual learning process of all partners involved – of scientists, students and teachers - (42 codings). The inquired students also indicated to wish to cooperate with experts (30 codings). These findings already give insight into chapter "3. Challenges and opportunities to transformational engagement, scientific literacies, and motivation".

Concluding with own reflections of the Austrian local Network team, as opportunities can be considered at the one hand, the insight into and the learning of new and other perspectives by means of the collaboration with students, teachers and scientists of different disciplines and on the other hand learning how to handle uncertain processes and outcomes which arise during and after the cooperation process. The uncertainty was even greater due to Covid-19 (see therefore: chapter 4 Covid-19 impacts). Challenges are especially the communication and organizational effort, which was time consuming and required a lot of flexibility. These challenges were also aggravated due to Covid-19 (for more information see also chapter 4).

Conceptual model(s)

Drawing on the general results of opportunities and challenges of open schooling generated within the transdisciplinary workshop, both teachers and students acknowledge a combination of school lessons, which are at the one hand teacher-centered, basing on knowledge transfer and on the other hand, a reorientation of the current educational system and curricula, which leaves space for students' engagement in transdisciplinary collaboration, as being valuable. The desire of transdisciplinary collaboration with out-of-school partners, especially scientists, and the valuable outcome of this kind of collaboration is also acknowledged in the standardized questionnaire and semi-structured interviews. The findings of the Austrian local assessment demonstrate, that the modules of the Austrian local network which base on a moderate constructivist approach of learning (Basten et al. 2015) and on the concept of inquiry-based learning (Pedaste et al. 2015) embedded in an inter- and transdisciplinarity context (Keller et al. 2019; Kubisch et al. 2021; Lang et al. 2012), are easy to integrate in everyday teaching activities, being a combination of knowlege-based learning and students' active engagment with real-world problems in transdisciplinary collaboration. At the same time the results show that this conceptual model can contribute to the claims of the Agenda 2030 and Education for Sustainable Developement of transformative learning, and quality education being participative, integrative and reflective (UNESO, 2021a; UNESCO, 2021b; Balsiger et al. 2017; Singer-Brodowski, 2016).

Updating and differentiating SEAS concepts, tools, and methods

The findings demonstrate that the conceptual modul of the Austrian local network, basing on the above mentioned apporaches can be successfully implemented. The conceptual approach has already been transferred to two further open schooling networks, the Department of Geography is collaborating with. Moreover, the amount of participating schools and scientists as well as institutions within the present and further networks has continously grown from the SEAS project start in 2019, showing that the conceptual model is easy to integrate in the existing formal school system.

The concept which is oriented on a touristic High Alpine Mountain Area needs to be adapted to be successful in other location. Moreover, the support of students by scientific expert and the Austrian local nework team has to be adapted to students need. Collaboration with high schools and federal colleges for economic professions and agriculture and nutrition as well as Rudolf Steiner schools so far, has shown that the concept can be easily adapted.

Applying the findings of the Austrian local network to the SEAS concepts and methods, the findings show that the conceptual models and methods developed in SEAS should at the one hand align with the existing curricula, which mainly base on knowledge transfer (at least in Austria), and on the other hand on carefully planned transdisciplinary modules, which allow students to work with out-of-school partners on real-world problems and which at the same time can be easily integrated in the existing curricula.

Identifying Dilemmas

The findings demonstrate that the existing educational system restricts the opportunities of open schooling partnerships and challenges collaboration activities. Schools are far away from fulfilling the objectives of the Agenda 2030 and Education for Sustainable Development, claiming that education has to be participative and support the generation of competences like the competency to learn from each other or to collaborate (UNESCO, 2021a; UNESCO, 2021b; Singer-Brodowski, 2019; UNESCO, 2017). Few innovative school formats or progressive modules within the existing educational system allow the implementation of open-schooling partnerships. However, the results confirm discussion about transdisciplinary research, that a lack of flexibility regarding time issues as well as additional workload aggravate collaboration. This is true not only for schools, but also for the out-of-school partners (Darnhofer et al. 2008). Additionnally, coming back to the students' statement that they do not feel taken in serious by the out-of-school partners, another challenge is to collaborate on an eye level, dismanteling hierarchies, in order to motivate fruitful collaborations (Cundill et al. 2019).

Reporting area 2, Austria: Challenges and opportunities to transformational engagement, scientific literacies, and motivation

One of the main premises in the SEAS project concerns the idea that, in order to address the important challenges of sustainability that we are facing, education needs to revise the ways in which scientific knowledge is understood and delivered in education, so as to become actionable and meaningful in real life contexts. As elaborated in the SEAS project description, a long tradition of socioscientific issues in education has shown how, when students engage in addressing real, complex problems, knowledge on scientific issues needs to be expanded so as to include personal as well as political dimensions. Local assessment in this area aims to document the forms of scientific literacies that emerge (factually or potentially) through open schooling collaboration, and how these relate to the participants' motivation for and agency towards knowledgeably addressing real life problems of sustainability. It also involves possible assessments on ways in which open schooling innovations present new or particular challenges to more traditional forms of teaching.

Data sources to be considered include but are not limited to questionnaire (including SEAS Global Assessment Instrument, GAI), interviews, and ethnographic observations of learning trajectories across contexts.

Methods

Data sources and Participants

1. Data about scientific literacy and environmental-friendly behavior was collected by means of a standardized questionnaire for N = 29 students, aged between 16-18 years, of an Austrian federal college which is part of the Austrian local network. The data was collected at the end of the only one Alpine Research Week (one of the transdisciplinary modules in the Austrian local network) which took place in September 2021.

2. Furthermore, students (N = 192) were queried by a standardized online questionnaire for the local assessment (general local assessment instrument) before and after having taken part at the Austrian local network. Please note, that these students did take part at almost all modules of the Austrian local network, despite of the Alpine Research Week, because of governmental restriction due to Covid-19. The modules the students took part were adapted to the Covid-19 situation and were particularly online. The N = 29 students who had the opportunity to join the Alpine Research Week did not yet receive this questionnaire, consequently they are not part of this evaluation.

3. The Global Assessment Instrument (GAI), a standardized online questionnaire for all SEAS local networks, was handed over to the students (N = 162) before and after participating at the local network. For this evaluation online the post-measurement is considered.

Analytical procedure and approach

1. The standardized online questionnaire, which was handed over to the students at the end of the Alpine Research Week in 2021 was descriptively analyzed by IBM Statistics 26. The questions base on a 6-Likert Scale (1 "I do not agree at all" to 6 "I fully agree"). The questionnaire measured students scientific literacy and environmental-friendly behaviour.

2. and 3. both the general local assessment instrument and the GAI were evaluated by means of IBM SPSS Statistics 26. The former was filled out by the students before the GAI. The local assessment questionnaire queried student's change in interest in climate change, responsibility, locus of control and climate-friendly behavior by means of a 6-Likert Scale (0 = "I do not agree at all" – 1 "I fully agree). The change was analyzed by means of a t-test for dependent samples. The GAI was analyzed descriptively. However, only results in respect to factors correlating with sustainable behavior are presented for this purpose. Correlation analysis was implemented by means of Pearsons r on a significance level of p = .050.

Please note, that all the results of the questionnaires base on students' self-evaluation.

Findings

The following findings base on a 6-Likert scale, ranging from 1 " I do not agree at all" to 6 "I fully agree", basing on the questionnaire which was handed over to the students after the Alpine Research Week. In the Alpine Research Week students do jointly research on climate change with scientific experts in different fields. In this Alpine Research Week students did research on climate change and tourism, environmental ethics, diet and glacier retreat. Focussing on scientific literacy, the students who took part at the Alpine Research Week acknowledged having learnt a lot about scientific processes (like formulating a research question and collecting data) (MV = 3.68) and having understood why science is important for everyday life (MV = 4.25) after having taken part at the Alpine Research Week. Moreover, students acknowledged to have learnt, how to apply scientific knowledge in everyday life (MV = 4.04) and how to argue scientifically (MV = 3.79). Additionally, they acknowledged to have learnt how to consider a problem from different perspectives (MV = 4.25). Considering climate-friendly behavior, student's awareness could be raised (MV = 4.33) and their knowledge about how to act climate-friendly (MV = 4.41). Moreover, their concern about climate change (MV = 4.22) and their system knowledge (MV = 4.48), the knowledge about how different spheres (e.g. climate change and tourism, glacier etc.) are interconnected, could be raised by inquiry-based learning embedded in a transdisciplinary collaboration with scientific experts. Furthermore, student's learnt how to critically consider own behavior (MV = 3.96) and their willingness to act climate-friendly could be raised (MV = 3.96). Additionally, students stated to be

more interest about the topic of climate change after having taken part at the Alpine Research Week (MV = 3.70).

Focussing on the pre- and post-test comparison of the general local assessment instrument, the findings reveal contradictory results. Please notice, that the students who answered these questionnaires did not take part at the Alpine Research Week due to Covid-19 regulations. The Austrian local network team elaborated alternative Alpine Research Weeks which instead took place at the site of the respective schools. Mostly the teachers themselves runned the alternative Alpine Research Weeks without the local network team and without scientific experts, since there were no external collaboration allowed/desired due to the regulations. Furthermore, also the other modules within the Austrian local network, particularly took place online and in a different form. The finding reveal that the interest towards climate-change could not be raised among these students, instead interest decreased significantly ($t = 2.220$, $p = .028$). In respect to responsibility to act climate-friendly, the same is true ($t = 2.129$, $p = .035$), the feeling of responsibility decreased significantly. Locus of control, the feeling to personally be able as well as society is able to contribute to climate protection, also decreased significantly ($t = 4.124$, $p = .000$). Regarding different dimensions of climate-friendly behavior there wasn't found a significant change in information seeking (e.g. discussing with friends and family about climate change, and seeking for information about climate change in media), however, mean values increased slightly, comparing pre- and post-test (MVpre = .4296 and MVpost = .4596). In respect to engagement (e.g. engaging in environmental organizations) there could be found a significant positive change after being part of the Austrian local network ($t = -2.153$, $p = .033$). In respect to everyday behavior (e.g. turning the heat off, not being at home etc.), there could not be found a significant change. It is assumed that the missing positive change and especially the negative change can be traced back to the Covid-19 situation, to students psychological conditions and to the particular missing support of the modules by the teachers (for more information see chapter 4). Moreover, comparing the results with the findings of the students who had the possibility to take part at the Alpine Research Week, the value of this transdisciplinary module becomes apparent, assuming that the missing Alpine Research Week could be a reason for the weak results.

Concluding with the results of the GAI, it shows that interest in scientific topics ($r = .469$, $p < .001$), scientific literacy ($r = .530$, $p < .001$) and knowledge of science ($r = .657$, $p < .001$) correlate significantly with sustainable behavior among the students who were part of the Austrian local network.

Implication to updating and differentiating SEAS concepts, tools, and methods

Taking up the results of the GAI, the results let assume that science education in SEAS needs to focus on raising students' interest, their scientific literacy and their knowledge of science in order to increase student's sustainable behavior. The concept of science education of the Austrian local network is promising, having a look on the above mentioned findings. Especially, the Alpine Research Week, where students do research on real-world topics together with scientific experts, raises both

interest and knowledge as well as scientific literacy. Moreover, the results show a raise in awareness of the need of climate-friendly behavior and engagement in environmental organization. The rather poor findings of the standardized questionnaire of the local assessment may be traced back at the one hand to the Covid-19 situation and the fact that not all modules could take place like in the common manner. For example, the kick-off event was online – supported by videos of experts, missing an active interaction with out-of-school partners - , the individual research projects were partly not guided by the teachers and the Alpine Research Weeks did not take place or where not supported by experts (see also chapter 4 Covid-19 impacts). Consequently, the transdisciplinary approach could not be implemented in a common manner. Focusing on previous school years in which the modules of the Austrian local network could be implemented in a common manner, interest and all three dimension of environmental-friendly behavior, self-efficacy and responsibility could be raised significantly (Kubisch et al., 2021 *in print*; Deisenrieder et al., 2020; Kuthe et al., 2019). As already mentioned above this concept can be applied in other geographical regions and to different school types, but of course it has to be adapted to the specific local conditions and to students' as well as teachers' needs.

Synthesis of findings

Conceptual model(s)

Since transformational engagment for sustainability is one of the SEAS aims and the GAI lets assume that interest, knowledge and scientific literacy are important prerequisits for sustainable behavior all of which variables could be raised by the didactical approach of the Austrian local network, the modular structure of the Austrian local network could serve as conceptual model for further open schooling intitiative. As already mentioned above the Austrian local network bases on different modules which are oriented on a moderate constructivist approch of learning (Basten et al. 2015), on inquiry-based learning (Pedaste et al. 2015) and on inter-and transdisciplinarity (Kubisch et al. 2021, Keller, et al. 2019, Lang et al. 2012).

The moderate constructivist understanding of learning originates from the idea, that learning is an active, situational, emotional, social and self-regulated process. Therefore, learning is considered as an constructive process, which builds on available conceptions, originating from individual experiences (Riemeier 2007, S. 69–70). In order to facilitate individual knowledge construction processes, students need both, the space to follow their interests and to tie up with their preconceptions and experiences (Widodo und Reinders 2004, S. 237–238), which is implemented by inquiry-based learning modules. Inquiry-based learning enables students to identify problems, build hypotheses, follow their own research questions, collect data and construct answers to their individual questions. From a pedagogical point of view, students are guided through this complex scientific process which is didactically reduced. Research studies in the field of inquiry-based learning demonstrate its potential in comparison to traditional teaching styles of direct instruction (Pedaste et al. 2015, S. 48). Furtak et al. (2012, S. 315–316) indicate a positive effect of inquiry-based teaching on students' learning in a meta-analysis and Pedaste und Sarapuu (2006, S. 48) show the application and generation of problem solving competencies during inquiry processes. Furthermore, the

European Commission acknowledged inquiry-based learning as an important and effective learning approach to build a scientific literate society (European Commission 2007, S. 2). The expansion of scientific literacy and a higher learning effect is also proven by studies in the field of moderate constructivist teaching and learning (Widodo und Reinders 2004, S. 233). The transdisciplinary approach in the Austrian local network bases on the idea of transdisciplinary research, which is a highly integrative and reflexive approach, integrating partners from science and society, cooperatively tackling social relevant issues, like CC. Societal partners are especially those who are affected by a problem and who have different experience and expertise on the issue. The process of dealing with these challenges is based on scientific research processes, and draws on diverse interdisciplinary methods, as well as a mutual exchange of knowledge and experiences, aims, interests and visions of science and society (Lang et al. 2012, S. 28–35). All partners are continuously involved in the scientific knowledge production process, coproducing knowledge for sustainable solutions as well as generating societal (e.g. community well-being) and scientific effects (e.g. new scientific insights) (Walter et al. 2007, S. 326–328). Aligning with transdisciplinary research, a socially relevant problem is the starting point of the transdisciplinary approach in the Austrian local network, being addressed in a dialogical manner between students and scientific partners.

However, before the collaboration between scientists and students start, a local assessment by means of a standardized questionnaire is carried out, followed by a kick-off event in which students get in dialogue with scientists, politicians, environmental activists and peers. Both discussion and an interactive part in which students discuss and share their opinion about climate change and sustainablity issues is part of the kick-off event. The kick-off event bases on a moderate constructivist and an inter- and transdisciplinary approach (Keller et al. 2019, Lang et al. 2012). During the school year the topic of climate change is integrated in every subject by the teachers. Before participating at the Austrian local network, the teachers take part at a teacher training, where they jointly develop the didactical principles of the Austrian local network (moderate constructivism and inquiry-based learning). Consequently, the teaching activities of the teachers should base on a moderate constructivist approach to learning. Moreover, during the school year the students do research on individually elaborated research questions and develop their research project. Students are free in choosing the topic, collecting data and in evaluating and presenting the results. They are supported by their teachers. At the end of the school year students join the Alpine Research Week, were they do research on real-world problems supported by scientific experts. In more detail, students do research on climate-related issues in the field of glaciology, tourism, environmental ethics, vegetation, soil and or nutrition. Finally, they fill out the general local assessment instrument which not only serves the Austrian local network team to scientifically evaluate the different modules, but also for reflection of the school year and the topic of climate change. The Alpine Research Week bases on moderate constructivism, inquiry-based learning and inter- and transdisciplinarity (Keller et al., 2019; Basten et al., 2015; Pedaste et al., 2015; Lang et al., 2012).

Identifying Dilemmas

See dilemmas in the other chapters.

Reporting area 3, Austria: Challenges and opportunities to teaching scientific literacy

Just as new or particular forms of interdisciplinary science learning for action and engagement towards sustainability are expected in open schooling innovations, new challenges and opportunities to teaching in these types of innovative settings are expected too. In this section, local networks are expected to provide with assessments on progress, challenges and opportunities documented in this regard. Particular emphasis is made to teaching strategies in the classroom, outside of the classroom, as well as on the collaborative challenges and opportunities that emerge in the collegial relationships, both within teachers and across teachers and school leaders.

Data sources relevant to this area include but are not limited to classroom and field (out-of-school) observations of teaching work, teacher planning meetings and meetings involving teachers and teacher leaders, as well as co-design workshops including teachers and focusing on teaching strategies or tasks.

Methods

Data sources and Participants

The data bases on own reflection.

Analytical procedure and approach

Own reflections base especially on the impressions and results of the Alpine Research Weeks, since the Austrian local network team is only part of the kick-off event and the Alpine Research Week. Science teaching in the class-room is in the hands of the teachers, however, how already mentioned before the teachers participate at a teacher training before being part of the Austrian localn netowrk. The teacher training provides an understanding of the didactical concept of the Austrian local network (Basten et al., 2015; Pedaste et al., 2015).

Findings

Previous findings within the Austrian local network and findings which are presented in this report regarding interest, knowledge, scientific literacy and climate-friendly behavior demonstrate that the concept of inquiry-based learning which is embedded in a transdisciplinary collaboration approach is successful. Especially, when it takes place outside the class-room and allows students active engagement, following their own questions of interest and doing research on real-world problems supported by out-of-school partners. However, some students also feel overwhelmed while having to take over responsibility for their own learning process and do research. So the experts and teachers have to be carefully aware of their role and need to adapt their suuport to students' individual needs.

Conceptual model(s)

Within the Austrian local network science teaching and learning occurs outside the class-room in an authentic learning environment in a High Alpine Mountain Area, in which students are actively engaged and do research on real-world problems supported by scientists. Teachers and scientists mainly have the role of coaches who support the students during their learning process and only give support if needed. For details to the conceptual model see above.

Updating and differentiating SEAS concepts, tools, and methods

Drawing on the findings, the SEAS concepts, tools and methods, need to be aligned on authentic learning environments, especially outside the school context, giving the students the opportunity to actively engage with a real-world issue.

Identifying Dilemmas

In order to achieve the demands of Education for Sustainable Development (UNESCO, 2021a) and Agenda 2030 (UNESCO, 2021b) and drawing back to the findings, science teaching and learning has to be rethought to be participative and reflective as well as to foster transformational learning and engagement as well as open up to the real-world (UNESCO, 2021a,b; Kyle, 2020; Keller, 2019; Balsinger et al., 2017; Singer-Brodowski, 2016). However, as already mentioned above, the current

educational system still builts some barriers for open schooling and is far away from fulfilling these demands (Singer-Brodowski et al., 2019).

COVID-19 Impacts

The Covid-19 pandemic highly impacted the Austrian local network. Reason therefore were amongst others the recurring lockdowns enacted by the Austrian government as well as home schooling which impeded teachers fulfilling the learning objectives of the subject(s) they teach. Thus, the crisis challenged the teachers which were part of the Austrian open-schooling network. According to the teachers, their priority was to fulfill the learning objectives which are anchored in the school curricula. Consequently, this made cooperation difficult in comparison to the first half of the cooperation in the school year 2019/2020. Especially, communication activities with the school partners were challenging. The team of the Austrian local network had to continously contact the teachers and ask them to participate in the respective activities which are part of the networks teaching and learning modules, many times it was hard to reach the teachers by telephone or email. This made communication activities extremely time consuming. The same was true for the out-of-school partners (e.g. scientists and local experts), which normaly voluntarely support the Austrian local network. According to their answers, after the lockdowns, they had so much work to do and were involved in many work and private meetings so that they could not find the time to support the network. Another challenge was the planning and organization of the kick-off event and the Alpine Research Weeks, which are two of the modules at which students take part in the Austrian local network. At the kick-off event about 300 students and their teachers meet, to get into dialogue with scientific and local experts, politicians, environmental activists and peers and interactively work on the topic of climate change. Whereas under normal circumstances the planning of the kick-off event is already very time consuming, which was the case for the kick-off event in the school year 2019/2020, the planning of the kick-off event for the school year 2020/2021 was characterized by uncertainty and difficulties. First the kick-off event was planned in presence, therefore many precautions were taken in order to fulfill the Covid-19 regulations (e.g. more conference rooms were rent with broader space; more experts were contacted to have some experts per conference room), the schools and experts were already contacted and a specific date for the kick-off event was determined. After having planned everything, new Covid-19 measures prohibited to perform the kick-off event on-site. Consequently, the Austrian local network team had to plan and organize the kick-off event online. Experts were successively invited to the University of Innsbruck to make professional videos in order to show the experts videos to the students in online kick-off events. The procedure and method of the kick-off was changed and adapted to the online situation. In order to fulfill the aims of the kick-off event and to guarantee the participation of each single student, which is more difficult online, the kick-off event was run with each school class individually. Therefore, instead of one kick-off event for all participating schools, the team of the Austrian local network had to support each school class individually. This was also very time consuming. Moreover, due to teachers prioritiy – fulfilling the learning objectives – the last kick-off event was run in March instead of at the beginning of the school year in September or the latest in October. Another challenge was the organization of the Alpine Research Week which normally takes place at the end of the school

year in June/July. In the Alpine Research Week, students do research on the topic of climate change in a High Alpine Mountain Area in different fields (tourism, environmental ethics, glacier, vegetation/soil, or newly elaborated nutrition) and are supported by scientific experts. At the last day they meet local experts to ask them about still open questions about climate change in the specific region. Due to the positive outlook in respect to the Covid-19 vaccination in Austria, the Alpine Research Week was planned on-site (the sites depend of the proximity to the schools, so that the journy is not to long). Two of the challenges were the communication and organization activities with teachers, since the teachers could not name specific dates for the Alpine Research Weeks due to the uncertainty posed by Covid-19. The team received the dates very late in the year and had to recruite the experts very spontaneously. It was difficult to find experts due to the time issue. Once recruited the experts and organized the overnight stays for the team on the sites, the Austrian government prohibited school excursions. The team had to cancel the experst and overnight stays as well as to plan an alternative research week for the schools. Some of the modules like for example the glacier module was designed online. And for other modules like for example tourism and environmental ethics new location independent concepts were elaborated, which allowed the teachers to run it individually with their students on the site of their school or online. Some of the teachers however, required experts or support of the Austrian local network team, so that the team's organization had to be flexible. Finally, one Alpine Research Week which was already planned for September could be runned with 33 students and three teachers on-site in the village of Schladming in a High Alpine Mountain Area.

Despite of the online adaption of the concepts of the kick-off event and the alternative Alpine Research Weeks, the successfull concept of the Austrian local network in terms of positively changing students environmental-friendly behavior in diverse dimensions as well as their interest in climate-change (see Kubisch et al. 2021 *in print*, Keller et al. 2019, Kuthe et al. 2019), which especially draws on inquiry-based learning and transdisciplinary collaboration in real-world learning settings, could not be achieved totally in the alternative (online) settings.

Concluding, the cooperation of this school year was characterized by uncertainty and challenges, however, also opportunities. Examples for the latter are the elaboration of new concepts for the SEAS k.i.d.Z.21 modules and the experience of learning how to handle uncertainty. Especially, challenging were the communication activities and the need to adapt the working activities to the new normal. Both was extremly time consuming.

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3. Belgium local assessment

Reporting area 1, Belgium: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships. The school and out-of-school interface.

Methods

Data sources and participants

In the Belgian local network, we focus the assessment of challenges and opportunities with regards to the establishment and implementation of open schooling partnerships on co-designing locally relevant teaching with the LORET tool. LORET is designed to support teachers in using locally relevant real-world problems as a starting point for education. The guiding principle is to offer students unique learning opportunities through combining engagement with societal problems and the realisation of curriculum objectives. 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. LORET has originally been used in several countries in Asia, Africa and Latin-America during the past 15 years. SEAS partner EduQuality and Leif Östman have then set up several collaborations to experiment with and substantially revise the methodology to also fit European contexts. The pilot trajectories in the Belgian SEAS open schooling network are part of this development. The collaborative work has continuously fed back into the LORET-homepage in order to update the materials, instructions, etc. offered to other partners in SEAS as well as stakeholders outside SEAS.

LORET pilot trajectories have been set up in 4 schools, in 1 of them in close collaboration with an environmental education (EE) centre and in all of them in collaboration with MOS[2], the Ecoschools programme of the Flemish government (see below):

- Primary school De Sterrebloem – topic: sustainable food production and consumption
- Secondary school Atheneum Merelbeke– topic: sustainable food production and consumption
- Secondary school St-Barbaracollege– topic: electricity and water
- In collaboration with EE centre Provinciaal NatuurCentrum (PNC): primary school Kindcentrum Straal – topic: biodiversity (we initially planned a collective LORET trajectory with several primary schools but because we found only one school which was able to participate, we changed the approach: see below)

[2] MOS = Milieuzorg Op School, the Ecoschool programme coordinated by the Flemish government

Furthermore, we connect our local assessment to the development of the (Belgian) SEAS library of lesson plans and teaching materials as a way to upscale the impact of the open schooling partnership beyond only the actors directly involved in the pilot experiments. The upscaling work in SEAS is led by EduQuality and its initial task was to develop one digital library to be shared by all SEAS partners. However, in close dialogue with UNESCO Paris and Scientix it was decided to develop one international library and offer the opportunity to develop national libraries in each country active in SEAS. Together with EduQuality it was decided to approach the Belgian open schooling network as a pilot project concerning upscaling through a national library. This is also connected to the task of EduQuality to develop a business plan in order to sustain the impact beyond the SEAS project's lifespan.

We collected data from the following sources through an intensive action research process in the four schools and the environmental education centre:

- Video- and audio-recordings of meetings + transcripts
- Video- and audio-recordings of LORET workshops + transcripts
- Field notes of meetings and LORET workshops
- Video- and audio-recordings of interviews with teachers + transcripts
- Documents (for content analysis): LORET-plans, lesson plans, teaching materials, student work, policy documents, emails, etc.
- Survey of teachers regarding sharing lesson plans and teaching materials
- Research literature

The table below presents a detailed overview of the data-set[3]:

DATE	WHAT	DURATION
29/08/2019	Preparatory meeting with pilot school 1	1h30
28/10/2019	LORET workshop with pilot school 1	4h
8/11/2019	Preparatory meeting with pilot school 2	1h30
10/12/2019	LORET workshop with pilot school 2	1h30
20/12/2019	LORET workshop with pilot school 2	1h40
23/12/2019	LORET workshop with pilot school 1	3h
30/1/2020	LORET workshop with pilot school 2	1h40
10/2/2020	Meeting with the Belgian Ecoschools (MOS)	3h
18/2/2020	Meeting with cCHANGE	1h20
3/3/2020	LORET workshop with pilot school 1	3h
6/3/2020	Interview with a teacher of pilot school 2	8'
13/5/2020	Meeting with SEAS partners Uppsala University and EduQuality	2h
2/6/2020	Meeting with the coordinator of pilot school 1 and a policy advisor of the Flemish Government (who is also head of the director board of pilot school 1)	1h20
5/6/2020	Meeting with SEAS partners Uppsala University and EduQuality	2h
15/6/2020	Meeting with the Belgian Ecoschools (MOS)	2h
27/8/2020	LORET workshop with pilot school 1	4h

[3] Grey shaded lines = data already included in the first annual local assessment report (D3.1).

16/10/2020	Interview with a teacher of pilot school 1	30'
22/10/2020	Preparatory meeting with pilot school 3	1h
23/10/2020	Meeting with the managing board of pilot school 2	1h30
8/12/2020	Meeting with the Belgian Ecoschools (MOS)	1h10
14/12/2020	Online LORET workshop with pilot school 3	1h20
22/12/2020	Online LORET workshop with pilot school 1	2h25
14/1/2021	Online meeting with 2 teachers of pilot school 1	55
20/01/2021	Online LORET workshop with pilot school 3	1h20
10/02/2021	Online LORET workshop with pilot school 3	1h45
15/2/2021	Meeting at pilot school 1	3h55
1/3/2021	Interview with a teacher of pilot school 1	1h40
19/3/2021	Interview with a teacher of pilot school 1	1h
19/3/2021	Interview with a teacher of pilot school 1	1h35
2/6/2021	Interview with a teacher of pilotschool 3	1h30
Spring '21	7 interviews with teachers and teacher trainers (Van Vooren 2021)	
10-27/6/2021	Survey of teachers regarding sharing lesson plans and teaching materials: Dutch questionnaire created with 'Google Forms' and spread by e-mail to relevant contacts and through relevant Facebook pages and LinkedIn groups	N/A
2/7/2021	Reflection workshop UGent-EduQuality on SEAS library and upscaling and sustaining impact	2h
6/7/2021	Meeting with MOS, KlasCement, EduQuality and UGent regarding SEAS library in the Flemish context	2h6
2/9/2021	Reflection workshop UGent-EduQuality on SEAS library and upscaling and sustaining impact	2h
17/9/2021	Meeting with the Belgian Ecoschools (MOS)	2h
29/9/2021	Meeting with environmental education centre PNC Limburg	1h44
4/10/2021	Meeting UGent, Steunpunt Leren en Diversiteit and EduQuality about how researchers and teacher training can play a role in upscaling and sustaining impact	1h30
11/10/2021	Meeting UGent, HOWEST and EduQuality about how teacher training can play a role in upscaling and sustaining impact	1h30
21/10/2021	Meeting UGent, Peer-to-Peer Foundation and EduQuality	2h
2/11/2021	Reflection workshop UGent-EduQuality on SEAS library and upscaling and sustaining impact	2h
10/11/2021	Online LORET workshop with pilot school 4 in collaboration with PNC Limburg	2h03
16/11/2021	Meeting with the Belgian Ecoschool coaches (MOS)	1h
17/11/2021	Reflection workshop UGent-EduQuality on SEAS library and upscaling and sustaining impact	
25/11/2021	Online LORET workshop with pilot school 4 in collaboration with PNC Limburg	2h36
1/12/2021	Meeting UGent, Peer-to-Peer Foundation and EduQuality	1h30
2/12/2021	Reflection workshop UGent-EduQuality on SEAS library and upscaling and sustaining impact	2h
N/A	Educational documents: LORET plans, assignments, teaching materials…	N/A
N/A	Policy documents: curriculum objectives, communication about modernisation of secondary education, ESE policy texts…	N/A
N/A	Local network documents: emails, information letters…	N/A

Analytical procedure and approach

Our overall research question is: How to optimally support teachers, schools and partners to design and implement high-quality open schooling about sustainability problems?

We address this overall question through the following sub-questions:

1. In which ways does the implementation of LORET disturb[4] the professional habits of teachers?
2. In which ways does the implementation of LORET disturb collective customs in school teams?
3. In which ways does the implementation of LORET disturb the habits of non-school open schooling partners?
4. Under which conditions do these disturbances result in a positively evaluated consolidation, enrichment or transformation of habits and customs?
5. How do facilitators of the LORET methodology affect this?
6. How can intermediary organisations (e.g. NGOs, environmental education centres, MOS) support teachers, schools and partners to design and implement high-quality open schooling about sustainability problems?
7. How do participants in LORET workshops learn from each other?
8. What is needed to upscale the pilot experiments' impact beyond only the actors directly involved as well as to sustain the impact beyond the three-years' lifespan of the SEAS project?

Investigating the disturbance and transformation of teaching habits through open schooling partnerships

Through qualitative analyses of interviews with teachers and partners in the pilot experiments and of LORET workshops and preparatory meetings, we investigate how implementing LORET-based open schooling challenges established teaching habits and routines and how this may result in a transformation of customary manners of teaching. The analyses focus on how teachers, school teams and non-school partners (incl. us as researchers) learn by doing through implementing the LORET methodology. Thus, the focus is on educators' professional development, i.e. the learning of teachers.

The theoretical framework that underpins our study is a transactional learning theory (Östman et al. 2019a) based on the pragmatist work of John Dewey (1916, 1938). This theory understands learning as being incited by a 'problematic situation' in which our habitual ways of acting and coordinating with the surroundings are disturbed. This is grounded in the pragmatist assumption that, in everyday life, we mainly act without reflecting. Reflection, and hence learning, first starts when our environment disturbs such habits. Sometimes we can easily solve problematic situations with the help of existing habits. Learning then results in consolidating and enriching the habit. But sometimes the problem is harder to resolve and requires an 'inquiry'. Through experimentation one tries to

[4] This term is related to the theoretical framework that we employ in this analysis: see further below.

solve the problem which results, if successful, in new knowledge, skills, values, identities, etc. Learning can in this case result in a substantial transformation of habits or even the start of a new habit.

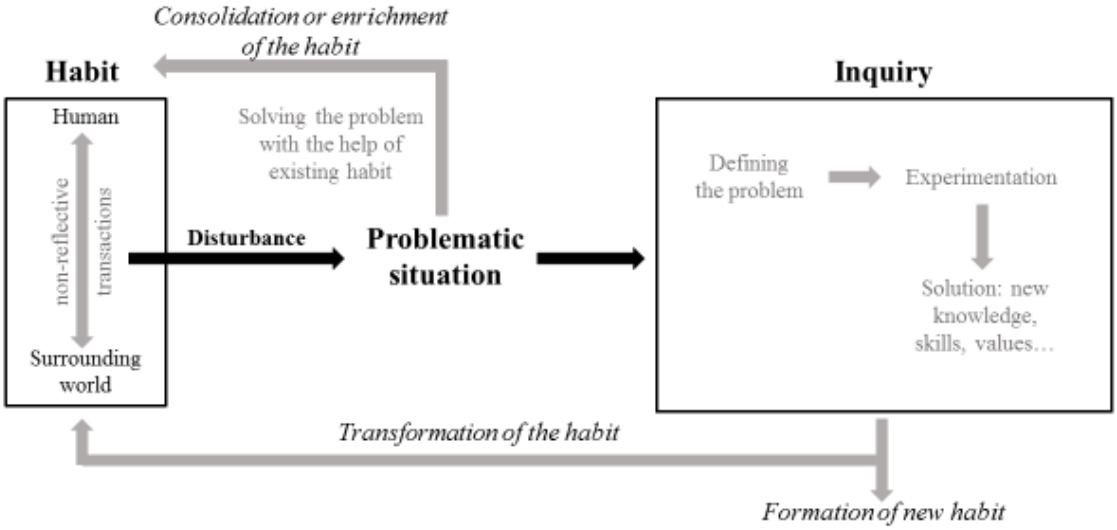


Figure inspired by Östman et al. 2019a

Drawing on this theory, we investigate disturbances of habits of teachers and partners as well as of collective customs of schools and partner organisations and whether/how the participants learn from these (i.e. consolidations, enrichment, transformation of habits and perhaps creation of new habits). Pragmatism's processual approach to the phases of habit, crisis and creativity that mark human action (Shilling 2008) offers a useful framework to investigate how the disturbance of teaching habits, incited by the introduction of a new open schooling methodology, may foster reflexive professional development and creative didactic innovation. It approaches learning as a dynamic *interplay* between analytically distinguishable yet intricately entangled intrapersonal aspects on the one hand and (interpersonal, institutional, material) aspects of the environment on the other.

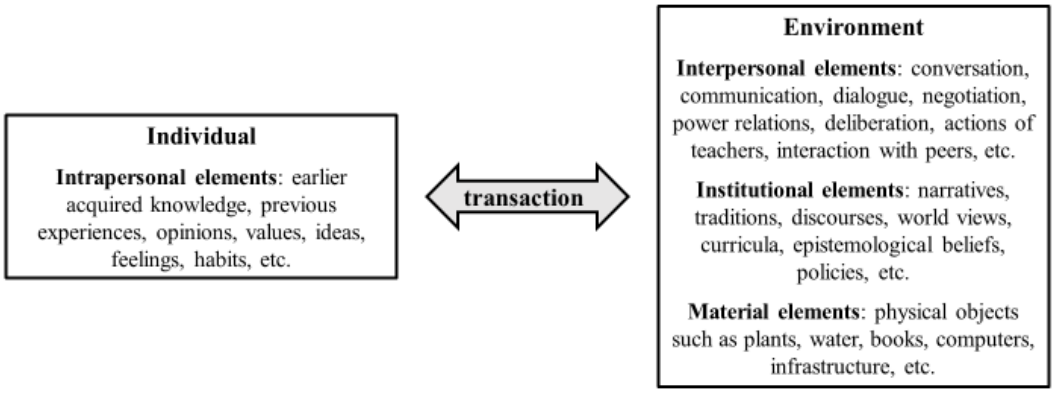


Figure inspired by Östman et al. 2019a

Our methodology consists of a 3-steps analytical procedure:

Step 1 is a thematic analysis of documents, interviews, field notes, and transcripts of observations in view of identifying disturbances of teaching habits (research questions 1, 2 and 3). We scrutinise the data looking for empirical evidence of 'problematic situations' (see above) and 'gaps' in the on-going discussions (see below) that reflect disturbances of professional habits and collective customs of teachers, school teams and non-school open schooling partners. These sensitising concepts – i.e. concepts that direct the researchers' attention towards interesting aspects of what is studied, relevant empirical evidence, fruitful lines of inquiry, etc. – derived from the above elaborated transactional learning theory and the below explained analytical method Practical Epistemology Analysis (PEA) constitute the initial coding scheme. The analyses of interviews complements those of our observations by also providing insight into the participants' intentions, reflections and experiences which sometimes remain invisible in observed activities. In that sense we can both capture observed and self-perceived/self-reported disturbances of habits and customs.

In Step 2, we analyse the transcripts of observations with the analytical method Practical Epistemology Analysis (PEA). The method was created by Wickman and Östman (2002) and has been applied in many empirical studies in didactic research. It is designed for analysing the making of meaning in encounters between people and their environment through a 'high-resolution' analysis of video/audio-recorded observations. We use it for analysing observed activities in order to generate findings from the empirical data that are subsequently explained with the above elaborated transactional theories of learning. A central assumption of PEA is that humans and their environment obtain meaning *in transaction*, reciprocally and simultaneously. Hence, meaning is not approached as something that exists as such, in itself, but instead seen as dynamically created and transformed in and by action, through the relations that are created by 're-actualising' prior experiences in order to make meaning of/in a new situation. Meaning is thus literally approached as something we *make*. PEA is a systematic analytical method to derive findings, out of the gathered empirical data, on how meaning is created in action by identifying the 'gaps' that occur when people encounter a new situation. Gaps occur in every encounter, yet are often bridged immediately. At times, however, the gap is too big to be bridged automatically and people hesitate, start to guess and make assumptions, disagree, ask for help, etc. They cannot simply proceed with their activity. These gaps are 'lingering gaps'. In order to be able to proceed, people need to create 'relations' between something that already 'stands fast' for them – previous experience, earlier acquired knowledge, skills, beliefs, etc. – and the new situation that is encountered. Meaning is made through the created relations. In terms of the transactional learning theory, we can say that a lingering gap confronts learners with a problematic situation that prevents them to continue habitually. Learning is assumed to have happened if the gap is successfully bridged by creating a relation to what stands fast. This becomes visible as the participants are able to proceed. Earlier experiences are 're-actualised' to make the new situation intelligible and the participants develop an expanded and more specific repertoire for action. Empirical analyses using PEA thus start with identifying lingering gaps that become visible through for example hesitations, questions, disagreement on how to continue, and subsequently analysing whether and how these gaps are filled through the created relations between what stands fast and what is encountered in the present situation. Filling a lingering gap often requires an inquiry. The learners – or the facilitators of learning processes – then

need to stage new encounters to fill the gap, for example, with a book, an expert, peers. Through PEA we can trace how a dynamic process of inclusion and exclusion steers the meaning-making towards certain learning outcomes. PEA, in combination with the transactional learning theory thus allows us to gain detailed insight in the *content* of meaning-making and learning, i.e. Which relations and, hence, meanings are created? What is privileged? What have people learned? Which habits are consolidated, enriched or (trans)formed?). It also enables progress of insight in the *process* through which learning occurs, i.e. Which encounters influence this? What is the impact of the teacher/facilitator? Of other participants? Of encountered objects?). As such, PEA allows researchers to open the black-box of learning processes and to deliver empirical evidence of whether, what and how people learn. We use it to address our research question 4 and to provide the foundation for addressing questions 5 and 6.

In Step 3, we further scrutinise the findings of Step 2 in order to reveal the impact of interventions of LORET workshop facilitators and intermediary organisations on the direction of the participants' learning (research questions 5 and 6) as well as how people learn from each other in the workshops (question 7). To reveal the impact of the LORET workshop facilitators, we identify the '**teacher moves**' (Östman et al. 2019b) that they perform, i.e. their interventions – which can be verbal as well as non-verbal – that guide the participants' learning by, for example, adding something to their attentiveness, steering the learning process in a certain direction or deepening it:

- **adding moves** influence the participants' learning by adding an object/phenomenon to be used in an on-going inquiry;
- **directing moves** affect the direction of the participants' learning by either affirming the pathway of inquiry (i.e. confirming moves) or changing it (i.e. reorienting moves);
- **deepening moves** affect the direction of the participants' learning by deepening the inquiry: here we can distinguish moves with a generating (e.g. generalising, specifying) and judging (e.g. testing, comparing) function.

Investigating how to upscale and sustain the impact of the pilot experiments

The last research question 8 – 'what is needed to upscale the pilot experiments' impact beyond only the actors directly involved as well as to sustain the impact beyond the three-years' lifespan of the SEAS project' – requires a different analytical approach.

We conduct **a qualitative analysis of documents, field notes, interviews, and transcripts of meetings in view of an 'internal analysis' of strengths and weaknesses** of the open schooling partnership, the actors involved, and the methods and tools used. Furthermore, we qualitatively analyse exploratory in-depth interviews with 7 teachers and teacher trainers and statistically analyse a survey for teachers (n=79) in view of an **'external analysis' of threats and opportunities** in the 'market' or target audience of the Belgian SEAS library/database of lesson plans and teaching materials. **A confrontation of the internal and external analysis results in identifying possible strategies for upscaling and sustaining the impact of the Belgian SEAS open schooling network** (Van Vooren 2021). Thereby, we pay attention to the needs and possibilities of teachers but also of intermediary organisations such as

NGOs, environmental education centres, and MOS that – already now or potentially in the future – (can) support teachers, schools and partners to design and implement high-quality open schooling about sustainability problems. This should reveal not only what kind of support is most needed but also how we can optimally prepare and equip intermediary organisations for, in their turn, supporting teachers, schools and partners.

Investigating open schooling partnerships in context

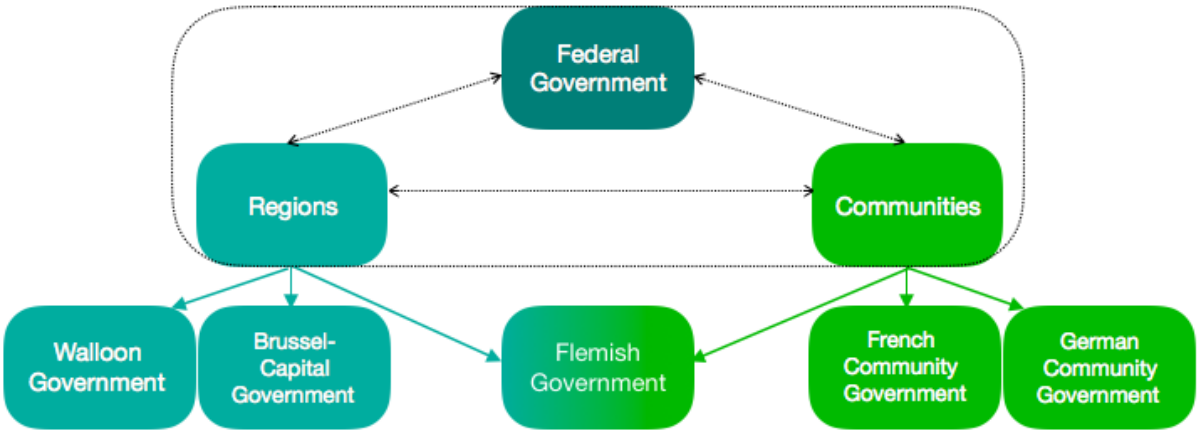
SEAS explicitly aims to investigate open schooling partnerships in a diversity of local contexts. Therefore, it is important to identify and take into account relevant characteristics of and tendencies in the specific context of the Belgian SEAS open schooling partnership. Partly, this is done through the external analysis mentioned above. Besides this, however, we also need to analyse and describe the specific policy context in which the Belgian SEAS network is established and implemented. This is vital for an adequate understanding of the disturbance of teaching habits and customs as well as for developing fruitful strategies for upscaling and sustaining the impact. Considering our strong focus on the LORET tool and this tool's explicit ambition to connect engagement with societal problems with the realisation of curriculum objectives, we pay particular attention to the curriculum policy in Belgium. This analysis is done by means of a study of literature and policy documents.

Findings

Context

Belgium's state structure, politics and governance

Belgium is a federal, decentralised, regionalised, constitutional monarchy with a bicameral parliamentary system. As a prominent EU Member State, it delegates some of its sovereignty to the EU's institutions on specific matters. The second of six Belgian State Reforms in 1980 established two regions: the Flemish and Walloon Region. In 1989 also the Brussels Capital Region was established. Henceforth, six governments (with regional unicameral parliaments and federal bicameral parliaments) are active in the Belgian polity: the Flemish Government, the French Community Government, the German Community Government, the Walloon Government, the Brussels-Capital government, and the Federal Government.



Belgium is characterised by a multi-party system, a proportionality electoral system and (large) coalition governments (Devos, 2006). Belgium is known for being the embodiment of 'highly complex institutional arrangements' and a consociational democracy (Schmidt 2003, p. 128). The 6 consecutive state reforms (between 1970-2011) currently shape Belgium's political contours and can be considered as institutional changes and extensive redistributions of powers (to produce more region and community tailored policies) with the intention of mediating and resolving political conflicts. Intra-Belgian politics is often regarded as conflictual, inefficient and rigid. In Belgium, there exists an 'extensive regional policy autonomy' and according to Jans and Swenden (2006) 'Belgian federalism was construed to require as little intergovernmental cooperation as possible' (p.886). This has led to 'policy divergences to emerge in policies such as education and the environment' (Jans & Swenden, 2006, p.888). The advantage of Belgian politics, in contrast, is that political crises are often evaluated as opportunities to contemplate or even initiate change.

Educational policy in Belgium and Flanders

Freedom of education is a Belgian constitutional right, which means that 'every (legal) person may organise education and establish schools to that aim' (European Commission, n.d). In Belgium, education is a community competence, so the respective community governments have the duty to organise undenominational education (European Commission, n.d.). The establishment, recognition, organisation and subsidisation of education by the respective communities is regulated by the Belgian constitution (Lesage et al., 2016). Since the pilot schools in the Belgian SEAS open schooling network are all located in Flanders (the northern, Dutch speaking part of Belgium), we focus on the Flemish education system and policy. National curricula are commonly the 'global benchmark', but the Flemish education system is an exception (Vanlinthout, n.d). For example, schools within the Flemish education system are given a lot of autonomy to focus on certain domains or they can also add certain development and education goals and competencies to the official curriculum (D'hoker and Henkens, in Daenekindt and Roose, 2015). Consequently, in such decentralised education systems, official, planned and realised curricula may differ significantly (Stevenson and Baker, in Daenekindt and Roose, 2015).

The Flemish Minister of Education is responsible for directing, monitoring and evaluating the Flemish education policy. The Department of Education and Training supports the minister with a wide range

of policy supporting tasks and prepares the final attainment targets ('eindtermen'). Final attainment targets are minimum objectives that the Flemish Government and Parliament considers necessary and attainable for a specific pupil population. Minimum objectives refer to a minimum level of knowledge, insight, skills and attitudes intended for that pupil population (Vlaamse Overheid, n.d.). Not the government, but the educational umbrella organisations and schools decide on the content of lessons, the teaching methods, the school's philosophy, curricula, timetables, staff appointments and pedagogical approach in view of realising the centrally developed minimum objectives. These umbrella organisations support and represent school boards. They also represent school boards in negotiations with the government. It is important to note that a considerable discretionary leeway exists for educational umbrella organisations, schools and their staff.

Most schools in Flanders are recognised by the government and hence financed and subsidised (for additional projects). Most education regulations apply to accredited schools. We can distinguish three educational networks: (1) community education (schools run by the Flemish Government), (2) subsidised free education (e.g. Catholic schools), and (3) subsidised official education (schools ran by municipalities or provinces). The main educational umbrella organisations are *Gemeenschapsonderwijs* (community education), *Onderwijsvereniging van Steden en Gemeenten* and *Provinciaal Onderwijs Vlaanderen* (subsidised official education), as well as *Katholiek Onderwijs Vlaanderen* and *Overleg Kleine Onderwijsverstrekkers* (subsidised free education).

In Belgium, all children from five to eighteen years old are subject to compulsory education. The duration of compulsory education is determined by the federal government (not by the regions). In general, a child moves from nursery school to primary school when s/he is six years old (i.e. on the first of September of the year in which s/he turns six). If the pupil has obtained a certificate of primary education (usually around the age of 12), after six subsequent study years, s/he can enter the first year 'A' of full-time secondary education. Children who have not obtained this certificate, attend the first year 'B' of secondary education. The first year 'B' is aimed at young people with learning difficulties or young students who 'prefer to learn by doing' (Vlaamse Overheid, n.d.). After the first year 'B', pupils can go to year '2A' (subject to a favourable decision by the admissions board), '2B' or to the first year 'A'. Secondary education consists of six or seven (in the case of vocational education) subsequent study years. This period of six study years is sub-divided into three so-called 'grades', each covering two study years (i.e. yeas 1 and 2, year 3 and4, and year 5 and 6). A student obtains the certificate of secondary education after the 2nd year of the 3rd grade general, technical or artistic education or after the 3rd year of the 3rd grade vocational education.

Primary school curriculum

In contrast to secondary education (see below), primary education is not (yet) the subject of a massive modernisation operation, but it is periodically updated. As mentioned above, the Basic Education Decree (25/02/1997) adopted by the Flemish Parliament, describes attainment targets as 'minimum objectives that the Flemish Parliament considers necessary and attainable for that pupil population. Minimum objectives mean: a minimum of knowledge, insight, skills and attitudes intended for that pupil population' (art. 44). Article 44 of the Decree further underlines that 'each

school has the societal task to reach the attainment targets regarding knowledge, insight, skills and certain attitudes at population level among the pupils and to pursue the attainment targets regarding certain other attitudes among the pupils' (art. 44). The Flemish Government or Parliament do not attach these developmental objectives and final attainment targets to 'learning areas' (subjects).

In line with the institutionally anchored pedagogical freedom in Belgium[5] it is a school board (with the support of the educational umbrella organisations) that is ought to make the connection between the final attainment targets and the learning areas included in this aforementioned decree. In addition, the school itself determines the content of the lessons and the teaching method(s). However, the Flemish government does impose some basic rules to ensure the quality of education. For example, at least the following learning areas must be covered in mainstream primary education: (1) Physical education, (2) Musical Education, (3) Dutch, (4) Science and technology, (5) Humanities and society, (6) Mathematical initiation (pre-school) or mathematics (primary education), and (7) French. In addition, in mainstream primary education, three themes are added across the different learning areas: (a) ICT, (b) Learning to learn, and (c) Social skills.

The Basic Education Decree also allows for critically evaluating the attainment targets: 'if a school board considers that the attainment targets or developmental objectives do not leave enough room for its own pedagogical and educational views or are irreconcilable with them, it shall submit a request for equivalence to the government by proposing replacement attainment targets and/or developmental objectives' (art. 44bis). The application is only admissible if it is precisely stated why the attainment targets or developmental objectives leave insufficient room for the school's own pedagogical and educational views or why they are irreconcilable with the targets or objectives. The school board proposes replacements for attainment targets or developmental objectives in the same application.

Article 47 of the Decree enumerates the elemental components a school board must include within its so-called 'school working plan': '1° the description of the pedagogical project being the set of fundamental principles established by the School Board for the school, 2° the organisation of the school and especially the division into pupil groups, 3° the way in which the learning process of pupils is assessed and how this is reported, 4° the provisions in ordinary education for pupils with a disability or who are learning disabled, including the forms of collaboration with other schools of ordinary and/or special education' (art.47). Besides a 'school working plan', Flemish schools also work with so-called 'curriculum plans'. These curriculum plans are a means for the educational umbrella organisation to maintain their own autonomy and educational freedom. The educational umbrella organisations expect their schools to follow the curriculum plans and therefore make use of inspection teams and pedagogical supervision services. The education networks and their

[5] Freedom of education is a constitutional right in Belgium since the 'Schoolpact' put an end to the so-called 'School War' in the 1950s. However, all schools seeking subsidy/funding from the government are required to use an approved curriculum. The inspection of the Flemish Community thus needs to approve a curriculum plan and, consequently, it will acquire official status.

affiliated schools thus have their own identities and also place their own emphases within the curriculum plans and school cultures. However, usually schools of the same educational network also share the same curricula.

In this regard, the discretionary leeway for the educational umbrella organisations, when developing and formulating curriculum plans, could potentially provide a window of opportunity for shifting schools' educational foci. In addition, each school can also decide what and how to evaluate progress regarding the achievement of the attainment targets among pupils. It is the school that is held accountable by the government for achieving the attainment targets, not the teacher or the individual student. What is also noticeable in the Basic Education Decree is art. 48, which states that '§ 1. Pupils shall receive twenty-eight instructional hours[6] of teaching and educational activities per week. § 2. By way of derogation from § 1, a twenty-ninth class period may be organised after consultation or negotiation in the local committee.' This implies that every primary school has the freedom to organise 1 extra hour-long teaching/educational activity every week.

Sustainability is not explicitly mentioned in the final attainment targets of primary education. Notwithstanding, 'people, society, environment and surroundings' have been assigned a key role. One can also observe that skills/attitudes such as 'openness' and 'critical thinking' are considered important final attainment targets during the learning process. Since the minimum objectives are very soberly formulated, they can be broadly interpreted. As we will also illustrate in our analyses, this means that – provided there is a willingness – untapped potential can be exploited by researchers, schools, teachers, educational networks, etc. There is (considerably) more educational freedom for schools and educational networks in primary education than in secondary education in Flanders.

As the final attainment targets largely affect the conditions for open schooling partnerships and are the basic building blocks for giving shape to teaching and learning in Flemish primary education, this local assessment scrutinises and analyses them in search of challenges and opportunities related to the three SEAS assessment areas (see below). In relation to the area of establishing and implementing open schooling partnerships, it is particularly relevant to contextualise the identified disturbances and transformations of teaching habits and customs (see below) in connection to the here elaborated institutional context.

Secondary school curriculum

Since the first generation of final attainment targets were introduced in secondary education in Flanders in 1997, updates have been made to a number of sets of attainment targets, however not in a systematic way. The need to modernise secondary education in Flanders was already stressed in 2003 by a commission of educational experts, labour unions and employer associations. They mostly focused on technology and autonomy for schools. In 2013, the Flemish Government approved a master plan for the reform of secondary education. In this master plan, the Flemish

[6] A teaching 'hour' in Flanders is a period of 50 minutes.

Government (2013) argues that 'Flemish pupils are scoring disappointingly in an international perspective on social and citizenship competences. Schools fail to seize opportunities to work on social emotional development and relational skills' (p.10). The master plan further explains that 'most secondary schools have a certain tradition of civic engagement, but do not actively position themselves in the social scene. They remain too much focused on themselves. Not only is there too little knowledge sharing and experience exchange within schools, but also between schools. Schools seek little contact and exchange little knowledge and experience with external organisations and the local community' (p.12).

In 2016, the Flemish Government approved two concept notes, which incited the rollout of the final measures of the master plan. In 2018, the Qualifications and Curriculum Department fleshed out the structural reform of secondary education with new attainment levels for the first grade of secondary education. The department collaborated in development committees – through 236 meetings – with the educational umbrella organisations, but also with teachers' associations and academic experts in order to obtain a broad input. Hereafter, a validation committee validated the (quality of the) attainment targets on the basis of the criteria of 'evaluability, consistency and coherence' (Vlaamse Overheid, n.d.). After obtaining a non-binding advice of some advisory boards, the Flemish Parliament adopted the decree in April 2018 that established the modernisation of the organisation and structure of secondary education. The modernisation of secondary education debuted in September 2019 in the first grade, to be then further introduced progressively – grade after grade. In February 2021, the Flemish Parliament approved the new attainment targets for the second and third grade of secondary education. By 2024-2025, the entire secondary education will have new final attainment targets.

The decree on educational objectives in secondary education states: 'the development committee formulates a limited number of soberly formulated, clear, competence-oriented and assessable attainment targets, development targets and specific attainment targets where the aspects of knowledge, skills, insights and, if applicable, attitudes are addressed.'(Vlaamse Overheid, n.d.). In secondary education, these objectives differ according to the grade and type of education (i.e. general, technical, artistic or vocational education) (Vlaamse Overheid, n.d.). All educational objectives are written according to a fixed format. In addition to the 'wording of the goal', each educational objective also includes a clarification of the knowledge required to achieve that goal, as well as an indication of the expected level of 'mastery' (Vlaamse Overheid, n.d.). According to the Flemish Government (n.d.), the new attainment targets are limited in number, clearly and 'evaluatively' formulated. Furthermore, the Flemish government introduced sixteen key competences (i.a. Sustainability; Citizenship; Spatial Awareness; Digital Competencies; Learning Competencies; etc.) which form the foundation of the educational modernisation. The learning outcomes and attainment targets are formulated according to these key competences, and no longer according to subjects or learning areas. According to the Flemish Government, the new set of attainment targets reflects the increased global complexity: compared to 20 years ago, more is expected from education today. In this way, the new attainment targets and key competences are

an expression of what society anno 2021 'demands' for education. The attainment targets will be periodically evaluated and updated if necessary.

In secondary education, it is also up to the education providers – mainly the umbrella organisations within the respective education networks – to link the attainment targets to subjects in 'curriculum plans' that are then implemented by teachers in the classroom. The connections between the educational targets, the subject(s) (clusters) and learning areas are made through the school curricula. This has led to a broadening of the curriculum. Education providers and school boards themselves can determine which attainment targets are achieved in which subjects, subject clusters or (cross-curricular) projects, as those targets are developed according to the key competences instead of subjects (as mentioned above). All recognised Flemish educational institutions and Dutch speaking educational institutions in Brussels are obliged to follow (a) curriculum(s) approved by the government (Vlaamse Overheid, n.d.). In a curriculum, the final attainment targets and developmental objectives set by the government must be included verbatim. The school board may add targets that it has explicitly formulated for its pupils (from its own educational project or from its own vision on a subject) and there must be sufficient room for the input of schools, teachers (teams) and pupils (Vlaamse Overheid, n.d.). As such, a curriculum plan sets out a strategy on how to adequately achieve the final attainment targets, and is supposed to foster flexibility and creativity among the schools on how to differentiate with an own interpretation and tailored learning content. In view of guaranteeing an equal level of education, the Flemish Government approves the curricula in accordance with criteria it has defined beforehand and on the advice of the Education Inspectorate (Vlaamse Overheid, n.d.). Subsequently, the Education Inspectorate assesses whether the attainment targets and the objectives of the curriculum dossier are achieved. The school-specific curricula are an additional instrument for the Education Inspectorate to assess the quality policy of a school (Vlaamse Overheid, n.d.). The Education Inspectorate does not make any judgements on the way in which a school organises its education practices ('the how'): for them, this is subordinate to the content of the education ('the what') (Vlaamse Overheid, n.d.).

Within the framework of the modernisation of secondary education, all education providers across the networks are jointly developing curriculum files per study area (e.g. Latin, Modern Languages, Economic Sciences, Technical Sciences, Construction Technics, etc) (Onderwijsvereniging van Steden en Gemeenten, n.d.). In this way, the curricula across the networks are more attuned to one another (Onderwijsvereniging van Steden en Gemeenten, n.d.). Each study area programme is accompanied by a so-called 'curriculum dossier' that the education providers draw up together. In such a file, the objectives (both the final attainment targets and professional qualifications as well as specific extension objectives) are clearly described. In this way, also the Flemish Government aims to achieve that the content of a course of study is more closely aligned across the educational networks.

As mentioned above, full-time ordinary secondary education in Flanders consists of three degrees, each consisting of two separate years of study. As a result of the modernisation, the six study years are restructured. The first year of the first grade consists of a common 'basic education' (of

approximately 27 teaching hours[7]) similar for all schools and 'electives' (of approximately five teaching hours) that can vary considerably from school to school. As mentioned above, the second year comprises two different paths (depending on whether you have passed the first year A): 2A and 2B. Path 2A is composed of a 'basic education' (of about 25 teaching hours) and an elective part (of about seven teaching hours). The elective part covers demarcated periods of 'deepening, exploration or remediation' of the basic education and some periods of 'basic options', which are 'focus learning packages' (Vlaamse Overheid, n.d.). Schools choose which and how many basic options they offer. Path 2B consists of approximately 20 teaching hours of basic education and approximately twelve elective teaching hours. This elective part consists of deepening and remediation and (a combination of one to three) basic options. This allocation of elective teaching hours can change annually. Due to the differentiation possibilities in the first grade, pupils have time to 'explore' with different study areas (Vlaamse Overheid, n.d.). In the second and third grade, various fields of study are distinguished. These fields of study are arranged in a matrix on the basis of eight study domains, three 'finalities' (with a focus on progressing towards higher education; with a dual focus on progressing towards higher education or entering the labour market; with a focus on entering the labour market) and four education forms (general secondary education, technical secondary education, artistic secondary education, and vocational secondary education). After the first grade, the student thus chooses a specific discipline/domain (i.e. a field of study with a specific 'finality'). Finally, in the third grade, various courses are subdivided into separate fields of study with different emphases to foster specialisation. Some examples:

	FINALITY with a focus on progressing towards higher education		**DUAL FINALITY** with a dual focus on progressing towards higher education or entering the labour market	**FINALITY** with a focus on entering the labour market
	Cross-domain (general education)	**Domain bound (technical and artistic education)**	**Domain bound (technical and artistic education)**	**Vocational education**
LANGUAGE AND CULTURE	Greek-Latin Latin Modern Languages Natural Sciences Humanities Economic Sciences *etc.*	/	Language and Communication Tourism	Hospitality and Leisure
STEM		Technological Sciences Construction Sciences *etc.*	Building Technology Biotechnology Electrical Engineering *etc.*	Construction Wood Mechanics *etc.*
ART AND CREATION		Architecture Visual arts Music *etc.*	Architecture Visual arts Photography *etc.*	Decor

[7] 50 minutes

AGRICULTURE AND HORTICULTURE		Bio-technical Sciences	Plant, Animal and Environmental Techniques	Plant, animal and environment
ECONOMY AND ORGANISATION		Business Administration	Business Administration	Organisation and Logistics
SOCIETY AND WELL-BEING		Social and Well-being Studies	Social and Well-being Studies	Hair and Beauty Care Health and Welfare
SPORTS		/	Sports	Sports
NUTRITION AND CATERING INDUSTRY		Bio-technical Sciences	Bakery Techniques Butcher Techniques *etc.*	Bakery Restaurant and Kitchen Butcher

Each final attainment target consists of a competence-oriented formulation in which the action verb (e.g. remember, understand, apply, create, etc.) expresses evaluable behaviour and 'guides the entirety of the attainment targets' (Vlaamse Overheid, n.d.). In addition, the necessary knowledge is explicitly mentioned as well as the applicable cognitive, affective or psychomotoric dimension of the attainment target. The knowledge is what is 'minimally required for the realisation of the final attainment target' (Vlaamse Overheid, n.d.). Therefore, this knowledge does not stand alone, it delineates the final attainment target and makes its content concrete. To specify the knowledge, the Flemish Government uses a classification of 'four types' of knowledge based on the revised taxonomy of Bloom: (1) factual knowledge, (2) conceptual knowledge, (3) procedural knowledge, and (4) metacognitive knowledge. According to the government, the above subdivision into types of knowledge does not imply a hierarchical relationship. Each knowledge category must be read and understood independently of the others. In addition, a final attainment level can contain several dimensions: a cognitive dimension, an affective dimension, and/or a psychomotor dimension. Again, Bloom's revised taxonomy is the basis for determining the various dimensions. The Flemish Government indicates that most attainment levels have a clear cognitive dimension.

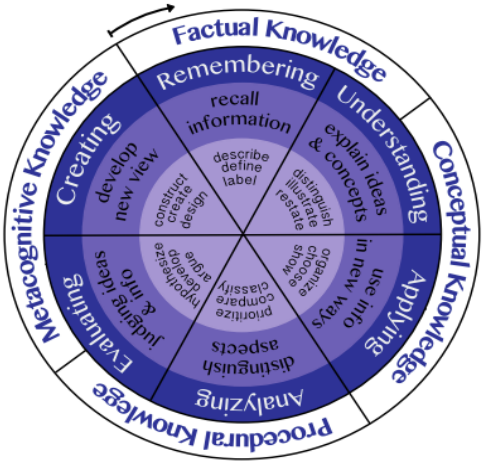


Figure: Bloom's taxonomy wheel revised - Source: Center for Teaching & Learning Excellence (University of Utah)

As mentioned above, the Flemish Government (n.d.) ostentatiously underlines that the 'ambitious and clear attainment targets' must be attainable for the schools and should offer the necessary space for schools to pursue their own goals. Therefore, the attainment targets remain minimum targets with sufficient space for schools to go further than what is laid down in the decree and to use their pedagogical freedom to include their own targets and implement their school-specific curriculum. What is new, however, in the on-going modernisation of secondary education, is that the final attainment levels determined by the Flemish Government need to be incorporated verbatim (which is not the case in primary education).

Controversy arose as several actors criticised and contested the reduction of pedagogical freedom in this modernisation operation. Katholiek Onderwijs Vlaanderen (i.e. the largest educational umbrella organisation in Flanders), together with the Steiner Schools and a number of art schools, requested the Constitutional Court to suspend and nullify the new attainment targets in the second and third grades of secondary education, on the grounds that 'due to the excessive scope and detail of the attainment targets, they pose a serious threat to both the quality and freedom of education' (Katholiek Onderwijs Vlaanderen, n.d). Katholiek Onderwijs Vlaanderen believes that free schools will no longer have sufficient room to elaborate their unique pedagogical project, as they argue that the attainment targets occupy the entire teaching time so that teachers are reduced to being the executors of a state pedagogy. The Constitutional Court did not respond to the request for suspension in the first place. However, the Court still has to rule on the appeals for annulment. For that reason, this local assessment will only focus on the new attainment targets that are already implemented (i.e. the first grade and the first year of the second grade).

As the Flemish final attainment targets largely affect the conditions for open schooling partnerships and are the basic building blocks for giving shape to teaching and learning in Flemish secondary education, this local assessment scrutinises and analyses them in search of challenges and opportunities related to the three SEAS assessment areas (see below). In relation to the area of establishing and implementing open schooling partnerships, it is particularly relevant to contextualise the identified disturbances and transformations of teaching habits and customs (see below) in connection to the here elaborated institutional context. Since the renewed attainment targets are currently in effect only in the first grade (i.e. year 1 and 2), and the first year of the second grade (i.e. year 3) we will focus on these specific operational attainment targets within this local assessment.

Environmental and sustainability education (ESE) policy

ESE policy in Flanders is both guided by international institutions and developments, and embedded in the Flemish overall sustainable development policy (Van Poeck et al. 2014). Several international policy initiatives have influenced and/or are affecting ESE policy in Flanders: the United Nations via the Decade of Education for Sustainable Development (ESD) from 2005-2014 and the associated UNECE Strategy for ESD, European Council Conclusions on ESD adopted in November 2010, the United Nations Sustainable Development Goals (SDGs), UNESCO's Global Action Programme on ESD, the Paris Agreement ratified by Belgium on April 6, 2017, etc. The Flemish Government's Department of Environment and Spatial Development is responsible for ESE policy preparation and implementation. A considerable number of civil servants are employed to realise the 'Programme Nature and Environmental Education' by facilitating networking, quality assurance, developing and disseminating expertise, implementing international policy initiatives, etc. (Van Poeck et al. 2018). Important vehicles to promote ESE in compulsory education and higher education are the 'eco-schools' (MOS) programme (Boeve-de Pauw and Van Petegem 2018) and 'Ecocampus' programme (Lambrechts et al. 2018) respectively. During the UNECE Decade as well as UNESCO's Global Action Programme, an 'ESD consultation platform' was installed as a coordination mechanism for stimulating implementation, information exchange and partnerships. It was given a mandate by the

Flemish Government and composed of representatives of diverse public administrations on different levels including ministers' political advisors and non-state actors such as NGOs, unions, institutes for higher education, school systems within compulsory education and strategic advisory councils (Van Poeck et al. 2014).

ESE policy in Flanders can be characterised as being not overly ambitious. In 2014, an analysis revealed severe criticism about a perceived lack of commitment on the part of the Government (Van Poeck et al. 2014). Representatives of the ESD consultation platform criticised the political commitment to ESD for being largely limited to paying lip service to policy objectives and for failing to translate these into tangible measures and to provide the necessary resources. ESD policy was argued to be 'extensively developed on paper' while 'the realisation in real terms is less obvious' (p. 701). The lack of commitment at the political level was seen to be partially compensated by initiatives at the level of public administration. In February 2018, the Flemish Government submitted the report on implementation of the UNECE Strategy for Education for Sustainable Development for which the Department of Environment and Spatial Development was appointed as a focal point. It should be noted that, although the format asked for detailed explanations, the Flemish responses in the report were rarely complete. According to the report, ESD is reflected in the policy document 'Vizier 2030'. However, this policy document never mentions ESD, but only vaguely makes reference to knowledge and skills to promote sustainable development.

Also in 'Visie 2050', which sets out a long-term vision for Flanders, ESD is not mentioned once. In the UNECE implementation report, the Flemish Government states that 'there are no public budgets or economic 'incentives ' available to lend support specifically to ESD' (p. 12). Also, project funds are not 'invariably focused on systematically promoting ESD' (p. 12). Furthermore, Flanders reports that 'ESD is reflected in policy and operational frameworks, but is not fully integrated in [a] consistent way' (p. 12), and Flanders expressed the need 'for a common understanding and the feeling of a sense of urgency' (p. 13). In the report, Flanders also explained that teaching and learning methods that support ESD were not addressed explicitly in the curriculum or programme of study at various levels of formal education, as 'institutions/learners develop their own SD/ESD indicators for their institution/organisation' (p. 19). Flanders also argued that there is no strategy/mechanism for 'encouragement of the development and production of ESD tools and materials' (p. 24) and no ESD teaching tools and materials are available for upper secondary education. No research in Flanders, according to the report, evaluates the outcome of the implementation of the UNECE Strategy for ESD. In the Flemish Minister's policy and strategy paper 'Education' for the time period 2019-2024, 'sustainability' or 'sustainable development' are never mentioned in conjunction with 'education'. The Flemish Coalition Agreement for this same legislature also never connects 'sustainability' or 'sustainable development' with education. Also, in the General Government Policy document 2019-2024, the words 'sustainable' or 'sustainability' are not mentioned once. In the policy paper (2019-2024) by the competent minister on Climate, 'education' is mentioned once and 'sustainability' is not mentioned. Only in the policy paper (2019-2024) by the Minister of Environment, education is regarded as a vehicle to effectuate the transition to a climate-neutral and sustainable society. The minister considers it necessary to prepare children, young people, students and, by extension, all

'learners' for taking on these challenges, as she acknowledges that pupils and teachers need support and training with respect to adequate climate knowledge. However, she does not elaborate extensively on this matter.

The Flemish Government is involved in the Belgian SEAS open schooling network through the Ecoschool programme 'MOS'. Founded in 2002 as a cooperation between the Flemish government's Environment Department, the Flemish provinces and the Flemish Community Commission in Brussels, MOS initially helped schools to develop their own environmental care system. Now, MOS coaches schools in determining a tailor-made path and timeframe, and offers substantive support regarding sustainability themes, such as climate, biodiversity, energy, et cetera. Through student participation, a sustainable learning and living environment is to be created in the school team and network. In this way, transversal and attitudinal goals should be achieved, while the other attainment targets receive attention in the classroom. In addition, MOS also provides various tools to work with the whole school on the SDGs and to integrate them into school actions, lessons and school policy. As we will show in our analyses, MOS is a very valuable partner in the Belgian open schooling network. Its revised philosophy and approach align very well with the network's focus on locally relevant teaching' (LORET). Its mission is formulated as follows:

> *'MOS strengthens schools to work on education with sustainability issues starting from locally relevant themes. MOS meaningfully connects these environmental and spatial themes that affect the school environment with the global Sustainable Development Goals. MOS does so by professionalising teachers and principals and supporting and inspiring schools with a whole school approach. MOS promotes an entrepreneurial environment for education for sustainable development (ESD) at school through networks and partnerships. In this way the school becomes a sustainable learning and living environment.'*

Educational assessments in Flanders

Some results of surveys and assessments that are conducted to evaluate, monitor and improve the quality of Flemish education are worthwhile to mention here in order to further illuminate the context in which the Belgian SEAS open schooling network operates.

The Flemish 'master plan for reforming secondary education' (2013) emphasises that the Flemish education system focuses to a limited extent on 'social relevance': 'Flemish pupils score disappointingly in an international perspective on social and citizenship competences. Schools fail to seize opportunities to work on social emotional development and relational skills' (p.10). The master plan asserts that 'most secondary schools have a certain tradition of civic engagement, but do not actively position themselves in the social scene. They remain too much focused on themselves. Not only is there too little knowledge sharing and experience exchange within schools, but also between schools. Schools seek little contact and exchange little knowledge and experience with external organisations and the local community' (p.12).

The results of the needs assessment in Flemish secondary education concerning world citizenship education (Catholic University of Leuven 2015) point to the 'need to connect with the local social

and cultural reality of the school when trying to introduce and stimulate world citizenship education and its global dimension in schools. This reflects the high priority that principals, teachers and pupils attach to finding answers to specific local societal challenges. These are local challenges around diversity, inclusiveness and equality, active citizenship, sustainability, etc. These are also challenges that schools are increasingly facing' (p.129).

In 2019, the survey 'People and Society' in primary education (2019) was carried out by order of the Flemish Minister of Education. The research was led by Prof. Rianne Janssen and coordinated by Dr. Koen Aesaert. For the examination on 'society', slightly less than half of the pupils (45%) meet the attainment targets. These specific attainment targets cover socio-economic, socio-cultural, political and legal phenomena. As far as professional development is concerned, the results show that approximately one in ten teachers have followed in-service training in the last two years (i.e. 2017-2018 and 2018-2019) on the content of the subject area 'people and society' (Steunpunt Toetsontwikkeling en Peilingen, 2019).

In 2016, the Flemish Community participated in the International Civic and Citizenship Education Study (ICCS), the largest international study of civic and citizenship education. 24 countries participated in the study. In Flanders, a total of 162 schools, 2,931 pupils in the second year of secondary school, 2,021 teachers and 149 directors were involved. The results of the ICCS report (2016) made it clear that Flanders remains far below the international average in terms of citizenship skills 'such as the intention to vote later or to participate in activities to help people in the local community' (ix), as well as that the 'attention paid to the active participatory aspect of citizenship education in schools remains very limited' (ix). Only 46% of the Flemish students indicate that they have learned about citizenship topics such as sustainability. In this regard, Flanders scores 10% worse than the international average. Furthermore, only 34% of the Flemish pupils indicate that they have learned at school about 'how you can contribute to solving problems in the local community' (p.79). This is 16% lower than the international average. Furthermore, Flemish pupils report that they get 'very few opportunities to participate at school. Only in the Netherlands and Estonia do young people get even fewer participation opportunities.' This may be a result of the fact that only 22% of Flemish teachers, when asked specifically about what citizenship means to them, indicate that promoting student participation at school is an important aspect of citizenship, and respectively 15% and 2% indicate that 'promoting youth participation in the local community' and 'preparing for future political participation' (p.116) are elementary objectives of citizenship.

Oproep voor een democratische school (OVDS) conducted a survey in May, 2019, among 3259 students from the third grade of Flemish and Walloon secondary school, to gauge their knowledge and their level of awareness of climate change (Hirtt 2019). In general, the survey noted no striking difference between French and Dutch speaking students. Apart from that, the results are concerning, as they reveal manifest sore points as regards to the current state and quality of climate education in Belgium. Only 13% of the respondents understand the greenhouse effect. In 2015, this number was 19%. In vocational education this score is abysmal with 4.6%. 40% of students mistakenly believe that transport by train emits as much or even more CO_2 per passenger than transport by car.

Awareness among students with respect to the huge North-South gap in the responsibility for climate change also remains very weak.

In addition, it is also relevant to consider the results of a survey — conducted in 2016 — among 430 students at 6 Flemish colleges of higher education in the second and third year of the respective bachelor studies 'primary education' and 'secondary education'. According to this survey, more than 80% of Flanders' future teachers believe that global warming is largely due to the hole in the ozone layer. Also 79.6% of future geography teachers (professional bachelors) are convinced of this theorem (Boussemaere, 2016). Regarding the survey question: 'What can you or your parents do to combat global warming? Mention a maximum of two examples that you think are important', more than 70% of future Flemish teachers can only think of climate solutions that either have little or nothing to do with global warming, or only plead for an individual change in behaviour that usually has little impact (Boussemaere, 2016). A negligible 0.6% to 2% of the respondents can think of an individual or collective action that should/could encourage the immediate (local) environment or the government to take more and better coordinated measures. Pieter Boussemaere, lecturer at the VIVES University College in Bruges and co-producer of the survey, argues that future teachers are unable to adequately educate pupils – with full knowledge of the facts – about one of the greatest social issues of the 21st century.

To feed the education policy and its stakeholders with extra tools and manuals, which are widely supported and adopted by teachers, the Flemish Minister of Education established the 'Better Education Committee' in 2020 to make concrete recommendations to improve the general quality of education in Flanders. The group consists of seven academic education experts and seven teachers, selected from a pool of 967 applicants. In October 2021, the Committee published an advisory report with 58 recommendations to boost educational quality in Flanders. One of it is: 'In addition to theoretical lessons and practical training, secondary schools can also offer an after-school social project by and for all their pupils. Jointly organised social service can strengthen empathy and increase the sense of citizenship. Social projects can also break down school walls and bring together the expertise of pupils from technical, artistic, vocational and general education. Of course, the supervision is important here and pupils must be encouraged to actively reflect on the what, the how and especially the why of the project. Such sustainable social routes are more effective than theoretical and/or reality-free citizenship lessons.' (p.64).

Disturbance of teaching habits and customs

Our thematic analysis of field notes, documents, interviews and transcripts of observations revealed varied ways in which professional habits and collective customs of teachers, school teams and non-school open schooling partners were disturbed by the introduction and implementation of the LORET methodology. We directly observed disturbances of habits during meetings and LORET workshops which became visible as 'gaps' in the conversations. Furthermore, the interviews and reflective expressions of teachers during meetings and workshops showed self-perceived/self-reported disturbances of habits and customs. Below, we describe which kinds of habits and customs were disturbed and illustrate this with excerpts from the empirical data.

The curriculum as a driver for lesson planning

Many teachers have the habit to plan their lessons starting from the subject content and the curriculum as it is outlined in the learning objectives (attainment targets but especially also curriculum plans) and textbooks (see below). Working with the LORET methodology can disturb this habit, as teachers are invited to plan lessons starting from a sustainability issue that is relevant in the local community and use that as a starting point to think about which curriculum objectives can be realised and how. We observed, for instance, how this affected the choice of sustainability problems to address as well as which students/classes to involve:

> *'For physics it's easier to work with wastage. Connecting physics to food is more difficult but it can be done.' (teacher)*

> *'I'm thinking about which students we can involve. For example, when I look at consuming sugars, I know perfectly how to involve those from the fourth grade, ehm, because there I teach regulation, for example, diabetes is addressed, that sort of things. So, I can incorporate that in my lessons, so I actually have an extra option. Ehm so that's food for example. And when I think of food, I also think of class 4B, our 'food and care' programme, who make their own meals for themselves but maybe that can also be opened up to school, to this campus that everyone can get soup in the afternoon. And so, I'm actually trying to find a link with all classes and all directions. While maybe if we go with waste or something about mobile phones, we can't actually involve a group of students, also in terms of curricula and those things.' (teacher)*

These sort of observations in each and every workshop made us strongly aware that, even when discussing real-world sustainability problems, teachers' focus is first and foremost didactical. Although they were invited by in the initial LORET methodology (see below) to put didactical considerations 'between brackets' in the first phases, these always emerged in one way or another. Acknowledging the advantages thereof, it became a trigger for revising the LORET methodology by strengthening the didactical focus from the start (see below).

The extent to which either the curriculum goals or concrete themes and problems serve as a starting point for lesson planning, differs considerably from school to school. This is illustrated by the example below of a teacher talking about how she does not necessarily start from the curriculum but adopted a more project-based approach:

> *'We work, for several subjects, with the curriculum objectives; more the objectives in our curriculum plan than the [general: see context] attainment targets. We have lists. For the more general subjects, we look at what goals we need to achieve. And then we work on them specifically. For world orientation, we look more at the themes that play a role in the class, and then we think during our preparation: and what goals are associated with that? Throughout the year we then look: Ah, these goals we have not dealt with yet, how can we integrate them in the children's projects?'*

Being prepared

In many teachers' habitual way of thinking and acting, it is of vital importance to be 'prepared' for the lessons. This is, for instance, reflected in the focus on 'lesson preparations' in teacher education

but also in school practice where teachers often use templates to plan each lesson in great detail in advance. Working with LORET-based open schooling was sometimes experienced as disturbing these habits and customs as it opens up a space for students' input – and, hence, spontaneity and creativity – which can, in somewhat unpredictable ways, affect both the content of lessons and the choice of suitable teaching methods and activities. This requires flexibility from the part of teachers for whom this can be experienced as a situation of being 'unprepared':

> *- Teacher 1: 'Isn't it an added value for many of those things if the ideas come from the students?'*
> *- LORET workshop facilitator: 'Yes. And that was also my question last time. There are actually so many possibilities to involve students themselves.'*
> *- Teacher 2: 'But then as a teacher you have to stay very, just neutral.'*
> *- Teacher 3: 'You have to do that anyway.'*
> *- Teacher 2: 'Then you must let everything come from the students.'*
> *- Teacher 3:'You have to do that anyway, remain neutral as a teacher.'*
> *- Teacher 2: 'No, no. But if you get input from them, […] That you hear different opinions and can pick up on them. But that you are not allowed to voice your own…'*
> *- Teacher 1: 'Don't stand there with a vegan sticker.'*
> *- Teacher 3: 'You know, what it is? That is also largely a matter of going to your lessons unprepared. Unprepared in the sense that you do indeed have to take in what the students say and get to work with it, and that is not easy for us.'*
> *- Teacher 2: 'I think you should, on the opposite, I think you should go to class prepared.'*

As a Flemish government representative at one of the workshop meetings framed it: a challenge for teachers in LORET workshops may be how 'to get prepared for being unprepared'.

Here, too, it is important to notice that these experiences can differs a lot from school to school. In an experience-based primary school (pilot school 1), for example, teachers appeared to be more disturbed by the extent to which LORET does require a certain form of preparation:

> *- Teacher: 'Well, that's what an investigation is… we usually know less about the end result or solution already. Now [while working with LORET] we had to record so much right away, while we often don't really do that. Because like I say, with a new project I often go my own way first.'*
> *- Interviewer: 'And do you mean that with LORET it is more certain where it will end up?'*
> *- Teacher: 'Yes, that we had to write a lot in those documents. Especially with the activities. Can you do that now? There was no other way, but it was also… Because the project… We knew every time we worked on it, that's for a long time. So, I found it difficult to say yes, we're going to do that.'*

Observations like these inspired us to revise the LORET trajectory so that the whole series of lessons does not need to be prepared all at once, from the start (see below). This is a way to meet the concern that it is difficult to plan all activities before knowing the students' input, but it can also allow teachers to feel better prepared if they get more time and support in planning and designing lessons after getting the – sometimes surprising, perhaps unexpected – input from students.

Being knowledgeable about the subject content

Related to the disturbance of the habit of feeling prepared, we also observed teachers experiencing a lack of content expertise on sustainability in general or on the specific sustainability issues they would address. Sometimes this regarded factual knowledge about certain problems and possible solutions, for example:

> *- Teacher 1: 'Seasonal vegetables. That you actually eat more seasonal vegetables instead of also in the summer er, also in winter… What is actually eaten in which season?'*
> *- Teacher 2: 'I don't know which vegetables are seasonal either.'*

It can also be about having a certain familiarity with the problems addressed and the practices of the non-school partners to work with, which is regarded important in order to connect out-of-school activities with teaching in the classroom.

> *'Not that I know everything about it, certainly not, but [since my husband use to have a community supported farm] I do have certain knowledge. But there are very few teachers who have that and I feel that myself at our school. The openness is there, the goodwill is there and all that, but you must already have some knowledge for that if you… When I go to the farm, I can already think a little and, I also learn a lot of new things, but I do have some knowledge that I can connect these things with. [One of our teachers] says it herself: I'm not going to do that because I don't know what to do there, what I have to do with it, afterwards right.' (principal/teacher)*

Very pertinent in the context of open schooling and, in particular, *locally relevant* teaching (LORET) is the repeatedly observed lack of knowledge of or familiarity with the local context. For instance:

> *- Teacher 1: 'It is difficult to empathise with challenges in a municipality where you do not live'*
> *- Teacher 2: 'For me too.'*
> *- Teacher 3: 'I agree'*

> *- Teacher: 'What I also found was that it was easier to find resources at school, but it was much more difficult to get resources in the neighbourhood. If you want to involve the neighbourhood of the school, the local residents, or the city. I found that a bit more difficult.'*
> *- Interviewer: 'And why do you think that was more difficult?'*
> *- Teacher: 'Uhm, I'm just thinking about communication. At school you know immediately, for that problem I have to go to that person. And in the neighbourhood, you do not know that immediately. For example, the city has so many different services and departments. That is already more difficult to know who should I actually go to and what should I actually ask.'*

We also saw teachers struggling with the boundaries of sustainability. Repeatedly they asked questions during workshops about whether or not certain aspects (e.g. animal rights, social issues) are relevant in a sustainability perspective. We also observed them discussing how to balance concretisation/specificity with avoiding that sustainability becomes a catch-all term. For example:

> *- Teacher: 'I think wastage is too specific, because if you look at product life cycle… you don't look at where things come from, how we design things to have less waste…'*
> *- LORET workshop facilitator: 'That's possible, you can think in terms of wasted materials…or wasted products.'*
> *- Teacher: 'But then everything is in it.'*

Teaching as lecturing

Most teachers are used to (being able to) provide students with the correct answers. When teaching about sustainability problems, they usually also offer the students knowledge and insight in the available solutions. In its striving to take students along in an authentic *quest for solutions* for real-world sustainability problems, LORET disturbs this habitual way of thinking and acting. The aim is not to provide all the answers and solutions, but to let the students generate these by offering them an authentic challenge and providing them with useful resources to explore the problem, to generate possible solutions and experiment with these (see also below).

> *'What I want to learn … a little more stepping away from the idea that it is me who needs to hand over all the subject knowledge and then really diving into the unknown and engage with a problem that I don't know everything about myself. And what my role will be then as a teacher, if I don't have all the answers ready.' (teacher)*

We sometimes observed how teachers found this difficult and, instead of planning lessons as an authentic quest for solutions, designed lessons as what we could call a 'pseudo-inquiry' set up to carefully steer students to outcomes already known in advance by the teacher. 'Let's pretend that…' was, for instance, something we repeatedly heard during LORET workshops. In the example below, a teacher explains his way of reasoning during an interview:

> *'I often pretend I don't know the answer yet. So, when students ask me a question, I sometimes reflect that question back to the class, even though I know it myself.'*

When it comes to offering students useful resources to engage in an authentic sustainability problem-solving process (see further below), we observed that teachers usually find it easier to select teaching content for exploring the problem than to generate, implement, and evaluate possible solutions.

> *'Unfortunately, I didn't get very far. I only find a great connection with exploring the problem from the perspective of geography. Implementing and evaluating solutions seems to me to be rather technical in nature and goes beyond the geography curriculum.' (excerpt from an email of a teacher)*

Being the teacher

As already shown above, teachers sometimes expressed a disturbance of their habitual way of perceiving themselves as a teacher by being confronted with the challenge to collaborate with non-school partners.

> *'And what my role will be then as a teacher, if I don't have all the answers ready. Or so, how to communicate […] with external parties, both within the school, the management, the school council, but also outside the school. How you can strengthen that communication. That there is no longer a boundary between within the classroom and outside the classroom, but that it becomes more of a whole. So that the different partners can work together and that it becomes more of a whole.'*

We also observed non-school partners struggling with a role that they are not used to playing: being involved in educative activities. Some partners asked questions about what exactly was expected from them or explicitly asked for pedagogical and didactical advice from the teachers involved.

> *- Partner [farm staff]: I saw after one year, if you think about it a little more deeply… I thought maybe we could do it again and just a little more thoughtfully. Not too structured – then it sometimes loses its spontaneity. But my expectation [for the workshop] today is also to see how I can get some more pedagogical input in all the things that are told to the children on the farm. How can I, as a guide or other possible guides, get some more pedagogical input? And I've already gotten a few hints. So, to see how that can become a bit more systematic in the future. And I am very curious to hear how what we have done has been reflected in the classroom. And what the teachers themselves think of linking to that, what is feasible? So that what we do on the farm returns to the school.'*
> *[…]*
> *- Partner [farm staff]: 'The minimum should be that it is all a source of inspiration somehow. And for me also for the way in which I discuss the topics, because we address a lot of things. […] That I get some return from the teachers. I mean, pedagogically, I approach the children in a different way.'*
> *- Teacher 1: 'That is a different way.'*
> *- Teacher 2: 'You are just [name] from the farm and not the teacher.'*

It is interesting to notice how the teachers see different yet complementary roles for themselves – as being the teacher – and external partners. This resulted in more explicitly recognising and valuing teachers' pedagogical/didactical competence and experience in the redesign of the LORET methodology with a stronger didactic framing (see below) and, for example, emphasising during the workshops that it is the teachers who are 'in charge' of planning and designing lessons for their students.

Relying on textbooks

Flemish teachers often use textbooks in their lessons (see also below: 'Upscaling and sustaining impact'). Sometimes these are just one of the sources of inspiration for some lessons, but sometimes teachers follow the textbook from the start to the end for teaching all their lessons. LORET-based open schooling requires teachers to, at least partly, create their own lesson plans and teaching materials. For several teachers, this is not their usual way of operating.

> *'I would dare to go a step further. I think I am familiar with the practice of guiding schools and teachers and I am nowadays very much in the flow of "don't set the bar too high", don't set your expectations too high. For example, what I have learned is that the knowledge of teachers about the attainment targets for primary education is not really there. I don't know about secondary education. I see the trend: the teachers just follow the method; they follow the textbook. They once had to learn the attainment targets, but they just follow the school's method now.' (MOS coach)*

> *- Teacher: 'I haven't been teaching for very long yet. […] I think that if you are in the training, in the teacher training, then you have to prepare everything down to the last detail. So, the start of your lesson and then your intro to the lesson and then on how to apply it and then repetition and then the evaluation and then the different phases. But because we have a textbook and that method is used,*

that's still... they do it less extensively, I must say. I sometimes realise that I have to go back even more to how it is taught in teacher training. [laughs]'
- Interviewer: 'But do you mean you can fall back on your manual because it's already so well thought out there and goes according to those phases?'
- Teacher: 'Yes yes yes, it's really like that yes.'
- Interviewer: 'So somehow you know, I'm safe if I follow this.'
- Teacher: 'Yes, I think so.'

Managing the workload

LORET emphasises the importance of simultaneously addressing sustainability challenges in the community and realising the curriculum. Thus, it is assumed to be a matter of 'doing things differently' without burdening the teachers with extra work. Yet, sometimes designing and implementing LORET plans is, by the teachers involved, experienced as 'doing extra things' anyway.

'We still have to discuss all of this in the team. I am very enthusiastic now, and there are more enthusiastic teachers here at school, but we have to monitor to what extent it is something that comes on top of it [the other work]. It has to be supported by everyone.' (teacher)

- Teacher 1: 'I think you can respond to it. So, you have a number of proposals from the students and they say, "OK I'll take this challenge". And if you notice that that challenge is not a challenge. Then of course you can address that.
- Teacher 2: 'Then you have to put a whole lot of energy into it. And time.'

Schedules

Relatedly, LORET-based open schooling can disturb teachers' and schools' practical planning and timing as it requires collaboration and coordination across subjects. Especially in secondary education where the different subjects are taught in time slots of 50 minutes by different teachers this can bring about a lot of practical and logistical challenges.

- Teacher 1: 'And what about doing it in class 4[X]?'
- Teacher 2: 'I don't teach in class 4[X]. Only 4[Y].'
- Teacher 3: 'I do teach in 4[X].'
- Teacher 4: 'I teach 4[X] but I don't have space to do this with them. I can't get everything done [without that extra activity] already.'
- Teacher 2: '[Teacher X – not part of the LORET team] also teaches there.'
- Teacher 3: 'But how much time will I need for that?'
- Teacher 1: 'Well if you do that reflection, then I think once a week for half an hour.'
- Teacher 3: 'But I only have one hour [in total].'
- Teacher 1: 'Ah yeah, because you teach geography. I think, these fourth graders, if you can do that with someone else.'
- Teacher 3: 'I can't do one class anyway, half an hour a week. Those reflections need half an hour once a week.'
- Teacher 1: 'I think there is... we should find out if there is another teacher in the fourth grade who has time.'

The habit of relying on habits

In line with Dewey's pragmatist writings about the role of habits in our lives, we observed how relying on habits is also – at a more meta-level – a habit that can be disturbed by introducing LORET-based open schooling. MOS coaches voiced their year-long experiences with teachers being 'tired of changes' and also teachers elaborated on it. For example:

> *- MOS coach: '[Flemish schools are] closed also in the sense of - I notice that very clearly - schools do not exchange and teachers do not even do that within the school. […] But another word is also weary of change. In education so many changes are coming, new focus, new frameworks, and teachers… it is becoming too much at some point. And also society puts more and more demands on schools.'*
> *- Researcher: 'I think in that sense that being careful is helpful, otherwise they may get overwhelmed.'*
> *- MOS coach: 'But it does make it difficult to do things like this. But maybe it is good. And certainly now with corona, it will be a struggle to find schools and enter into interesting collaborations.'*
>
> *'I think quite often when something new comes in, then I think, oh no, something new again. It's already so much. And something in me makes me stiffen a bit, and I can't just, like, ah, ok I'm going to do it, we'll see. That never works. I always have a mini resistance like that. But then I kind of watch out, or I do something small. But I can't do anything right now that I really don't feel for.' (teacher)*
>
> *'So, about the last [LORET] sessions [making the LORET plan] I was sometimes a bit frustrated. I wasn't in the mood to, I don't know now if we finally did, but to use your templates. I didn't really like that that much. Because, I just said it, I feel a bit of resistance from myself, that may be a bit pubescent, but that is certainly not to be "anti" or something. But then I think to myself, do I have to do it like this now because that's what your system is requiring? But for me that is now, that bit of added value, I had a bit of trouble with that. If we just put that [templates for preparing lessons that we already use] in LORET it's basically the same thing. Then it isn't something else again. Where does that take us, you see?' (teacher)*

Conclusion

It is obvious that introducing LORET brings about some disturbances of habitual manners of teaching and of the established routines in school (teams). A summary:

Disturbed teaching habits and customs
The curriculum as a driver for lesson planning
Being prepared
Being knowledgeable about the subject content
Teaching as lecturing
Being the teacher
Relying on textbooks
Managing the workload
Schedules
The habit of relying on habits

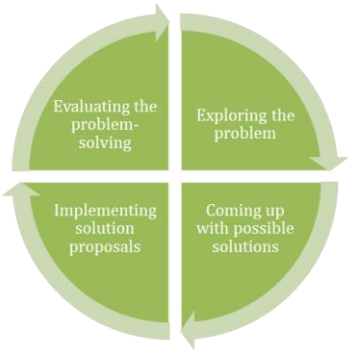
In the next section we address how some of these disturbances may be related to the institutional context in Flanders. Subsequently, we explain and illustrate in which ways our open schooling

partnership managed to contribute to overcome these disturbances and, thus, what can be fruitful drivers for a transformation of habits and customs.

Working with LORET in the context of the Flemish curriculum

The way in which introducing LORET-based open schooling disturbs teaching habits and customs is not only affected by teachers' habitual, personal manner of teaching or by the specific culture and organisation of the participating schools. Also the institutional context of education in Flanders with its specific curriculum characteristics (see above) plays an important role in affecting whether and, if so, which teaching habits and customs are challenged by working with LORET.

LORET aims to support teachers in the didactical work of taking their students along in an authentic problem-solving process. Going through the four phases of a full problem-solving cycle – exploring the problem, coming up with possible solutions, implementing solution proposals, and evaluating the problem-solving – the students are supposed to encounter a variety of questions with valuable pedagogical potential (see table below).



Steps of a problem-solving process	Questions
1. Exploring the problem a. Gathering information b. Analysing information	▪ What is the problem? ▪ How significant is the problem in the local community? ▪ Are there different approaches and opinions regarding the problem? ▪ What do we know about it? ▪ Why is it happening? What are the root causes?
2. Coming up with possible solutions a. Generate possible solutions b. Select a solution proposal	▪ What shall we do about it? ▪ What are alternative ways to solve the problem? ▪ Do the proposed actions have significance when solving the problem?
3. Implementing solution proposals a. Plan the implementation of the solution proposal b. Implement the solution proposal and document	▪ What actions shall we set up? ▪ Where? ▪ When? ▪ With whom?
4. Evaluating the problem-solving	▪ Have we solved the problem or are there still aspects that needs attention? ▪ In which way did we contribute to solving the problem? ▪ Did the plan work? ▪ What can be improved on what we have done? ▪ What needs to happen next?

Our analysis of the disturbance of teaching habits and customs (see above) reveals that it appears to be particularly challenging for Flemish teachers to identify teaching content and design lessons situated in the phases beyond exploring the problem. Providing the students with resources and activities to generate and/or implement solution proposals, for example, turned out to be more difficult. This observation encouraged us to **investigate whether and, if so, how the curriculum**

objectives – and, hence, curriculum plans and textbooks – facilitate and/or encourage that. As it is impossible to systematically screen all the different curriculum plans that vary across education networks, umbrella organisations and sometimes even at the level of individual schools (see above: context – educational policy), we screened the attainment targets in relation to the 4 phases of the problem-solving cycle. Important to emphasise before we present some findings, is that the 'pedagogical freedom' that is guaranteed by the Belgian constitution is reflected in so-called 'soberly formulated' – which often means vaguely, abstractly and/or formalistically formulated – attainment targets (see above). This means that it was in our screening often not possible to unambiguously connect one target to one particular phase of the problem-solving cycle. In many cases this would depend on how an umbrella organisation or a school operationalised the attainment target into an objective in their (various) curriculum plans. To give but one example: the target 'the students can carry out small motor skills in various situations with sufficient motivation and execution' *can* be addressed through tasks and activities in the phase of 'implementing solution proposals' in a problem-solving process, but a school/teacher can also realise this target through teaching activities that are not at all connected to authentic problem-solving activities. Furthermore, it is not always possible to connect the targets to a specific school subject as it often belongs to the pedagogical freedom of the school or education network to decide which subjects will be employed to realise the targets. Due to these challenges, we opted for researcher triangulation (Patton 2002) and involved two different researchers (i.c. Nordin Bigaré and Katrien Van Poeck) in screening the targets and discussing the results.

Below, we present a non-exhaustive list of examples that illustrate how the different phases of the problem-solving cycle are addressed in the attainment targets of both primary and secondary education in Flanders.

We found a lot of attainment targets that are connected to the phase of '**exploring the problem**'. For example, in primary education:

- *Students can acquire and use coherent information (including information other than texts) in a systematic way.*
- *Students can localise hazardous traffic situations in the wider school environment.*
- *Students are able to illustrate that labour migration and the issue of refugees have played a role in the development of our multicultural society.*
- *Students are able to measure, compare, and describe weather elements at a specific time and over a limited period of time.*
- …

In secondary education:

- *Students apply the scientific method step-by-step to investigate a problem.*
- *Students explain the complexity and interconnectedness of sustainability issues.*
- *Students extract subject matter and relevant information from written and spoken nonfictional texts as a function of purposeful information processing and communication.*
- *Students examine spatial effects of changes in landscapes on people and their habitats.*
- *For a biotope, students examine the interdependence of different organisms and the role of biotic and abiotic factors.*

- *Students use appropriate measuring instruments, measurement methods, and tools with accuracy to make measurements, observations, experiments, and field studies.*
- *Students evaluate the context, reliability, representativeness, and usefulness of historical sources in light of a historical question.*
- *Students examine spatial effects of changes in landscapes on people and their habitats.*
- *Students formulate a research question for a defined problem using provided criteria.*
- *Students formulate an answer to a research question or hypothesis using provided guidelines.*
- *Students reflect on philosophical anthropological views using philosophical concepts.*
- *The students investigate interactions and processes in ecosystems.*
- *Students reflect on ethical movements and issues using philosophical concepts.*
- *Students analyse interactions within a building and between a building and its environment.*
- *Students investigate concrete situations related to human rights.*
- *Students illustrate social justice and injustice using specific examples.*
- …

Attainment targets related to the phase of '**coming up with possible solutions**' were scarcer in the Flemish curriculum although some targets definitely provide opportunities for it. For example, in primary education:

- *Students can provide suggestions for designing their own environment.*
- *Students demonstrate a willingness in their behaviour to be careful with waste, energy, paper, food and water in their own classroom and school.*
- *In a non-conflict-laden situation, students spontaneously express their own impressions, feelings, desires, thoughts, and appreciations.*
- …

In secondary education:

- *Students generate ideas for a challenge using provided techniques and methodologies and within a structured and defined framework.*
- *Students justify choices they make to solve a mathematical, science, technology, or STEM problem.*
- *Students explore the feasibility of ideas taking into account provided criteria.*
- *Students develop a solution to a technical problem by applying insights, concepts, and skills from different STEM disciplines in an integrated manner.*
- *Students apply a scientific method to develop knowledge and answer questions.*
- *Students use provided strategies to engage in informed dialogue about societal challenges.*
- …

The same goes for the subsequent two phases of the problem-solving cycle. Examples or attainment targets connected to '**implementing solution proposals**' in primary education are:

- *Students are able to perform basic care tasks independently when caring for animals and plants in their environment.*
- *Students can solve simple problems in a systematic and insightful way.*
- *Students demonstrate a willingness in their behaviour to be careful with waste, energy, paper, food and water in their own classroom and school.*
- …

And in secondary education:

- *Students go through a problem-solving process that integrates knowledge and skills from multiple STEM disciplines.*
- *Students employ strategies for dealing respectfully and constructively with individuals and groups in a diverse society.*
- *Students use strategies to reach constructive solutions to conflict situations.*
- *Students act sustainably in a school context.*
- *Students perform an iterative engineering process across the experience areas to realise a simple engineering system from need(s) and criteria.*
- *Students adopt health-promoting behaviours within the school context from an understanding of the importance of prevention and potential risk factors.*
- *Students systematically execute a solution strategy in response to an inquiry or problem.*
- *Students actively contribute to the development of a common outcome in group activities with a well-defined task.*
- *Students illustrate how to engage and take action individually and as a group member on local, regional, national, or global issues.*
- *Students use their expertise and artistic talents for a common purpose or project.*
- *Students employ strategies to interact respectfully and constructively with individuals and groups in a diverse society.*
- *Students act with the goal of sustainable development.*
- …

'Evaluating the problem-solving' can be done in primary education through the following targets:

- *Students can illustrate that different social and cultural groups possess different values and norms.*
- *In a non-conflict-laden situation, students spontaneously express their own impressions, feelings, desires, thoughts, and appreciations.*
- *Students are willing to ask themselves questions about their approach before, during, and after solving a mathematical problem and want to adjust their approach based on these questions.*
- *Students can recognise steps of the technical process (posing the problem, developing solutions, making, putting into use, evaluating) in concrete experiences.*
- …

In secondary education we found the following examples:

- *Students assess both the importance of an assignment to themselves as learners and the relationship between their own and the competencies required to complete the assignment.*
- *Students reflect, using guiding questions, on the impact of their own and others' learning beliefs and strategies on the completion of an assignment.*
- *Students reflect on ethical movements and issues using philosophical concepts.*
- *Students will apply a scientific method to develop knowledge and answer questions.*
- …

Our screening exercise revealed promising pathways for future research, i.e. to screen objectives at the more concrete and operational level of the curriculum plans in order to systematically and more unambiguously (see above) assess how much each phase of the problem-solving cycle is addressed, to test our hypothesis that the three later phases receive less attention than the first one, and to conduct comparative research across different education networks/umbrella organisations. Thinking in terms of 'challenges and opportunities' for open schooling, the 'sober formulation' of attainment

targets can be seen as opening-up a window of opportunities. As a MOS coach has formulated it: *'They may be vaguer, but they have the advantage that they can give you a very broad view'*. A question arising, then, is to what extent this opportunity is grasped. Furthermore, it would be interesting to investigate this also in textbooks. As many teachers heavily rely on textbooks (see above), they may give us reliable and very concrete information of whether and how sustainability problem-solving is addressed in Flemish classrooms.

Overcoming disturbances: Transformation of teaching habits

After gaining insight in how the introduction and implementation of LORET can disturb habits and customs, **we explored how teachers, school teams and partners are able to overcome these 'problematic situations' and how it may result in a transformation of customary manners of teaching that allows them to (better) implement LORET-based open schooling**. As explained, we do so by using PEA as an analytical method and the transactional theory of learning as an analytical model. This allows us to gain insight into how educators' professional development, i.e. the learning of teachers, comes about through a dynamic interplay between analytically distinguishable yet intricately entangled intrapersonal aspects (people's previous experiences, earlier acquired knowledge and skills, their established values and beliefs, etc.) on the one hand and aspects of the environment of the open schooling partnership and experiments on the other. The latter involves interpersonal aspects (interactions with other teachers, researchers, non-school partners, etc.), institutional aspects (curriculum, policy, school culture, prevailing discourses, etc.), and material aspects (the physical environment, material tools used, etc.). Below, we describe how we observed different ways in which disturbances of habits and customs can be overcome and illustrate these with excerpts from the empirical data.

Teachers learning from each other

We repeatedly observed examples of 'collegial learning' where teachers overcame problematic situations by drawing on each other's input in the discussions. In PEA terminology (see above): in the *encounters* with colleagues, teachers were able to create fruitful *relations* that helped them to bridge *gaps*. They inspired and learned from each other in diverse areas.

An important problematic situation in relation to open schooling – and LORET in particular – where we saw teachers helping each other concerns how to link a sustainability challenge to their subject-specific curriculum. An example related to the disturbed teaching habit 'The curriculum as a driver for lesson planning' (see above):

- *Teacher 1: 'For physics it's easier to work with wastage. Connecting physics to food is more difficult but it can be done.'*
- *Teacher 2: 'Biofuels'*
- *Teacher 1: 'Yes, biofuels'*
- *Teacher 3: 'Food miles'*
- *Teacher 1: 'Yes, that's right.'*

Teachers also learned from each other how to organise things practically in a way that they can manage the workload as well as challenges related to their usual schedules (see above). For example:

- Teacher 1: 'Then an important point is once or twice a week, depending on how many teachers participate in a class, is to delve deeper into those reflections. And through a class discussion actually…'
- Teacher 2: 'What once or twice a week?'
- Teacher 1: 'Yes.'
- Teacher 3: 'During the lessons, right?'
- Teacher 1: 'During that month yes.'
- Teacher 3: 'O? Yes…'
- Teacher 2: 'But I only have two hours.'
- Teacher 3: 'But you don't have to do both those things. So, if I do it once, for example, and another teacher does that once.'
- Teacher 1: 'How I was thinking, for example, in the third year, I think, you teach foundations [of democracy] in the third year.
- Teacher 3: 'Hm.'
- Teacher 1: 'I see them once for physics. I do a reflection, but then also more regarding: does this really have an influence? Calculation and so on. Another reflection can then be with you for example.'
- Teacher 3: 'With more social aspects, then. How did that affect you?'
- Teacher 1: 'Indeed, that's why I also said one or two times a week.'
- Teacher 3: 'And then we've already had it twice.'
- Teacher 1: 'And we can alternate that too. The following week it will be someone else and then… If we agree on that, we might lose an hour at most.'

Also when it comes to overcoming a lack of knowledge about the sustainability challenges in focus (see above) we observed teachers learning from each other, for instance while discussing aspects of the issue of sustainable food production and consumption:

- Teacher 1: 'I also thought for physics, biofuels that are also crops that they grow. And uh I don't know.'
- Teacher 2: 'Yes, that will also have something to do with it.'
- Teacher 3: 'Yes actually. But of course, that is not food that you eat but it is, I don't know.'
- LORET workshop facilitator: 'At least it has a link.'
- Teacher 4: 'The production, the production at least.'
- Teacher 3: 'That is food that is lost to humans.'

Interventions of LORET workshop facilitators

A second type of encounters that helped participants to bridge gaps and, thus, to 'learn a way out' of disturbed habits, are those with LORET workshop facilitators and their actions during the workshops.

Here, we present an example of how the interventions of the workshop facilitator helped teachers to find ways to work interdisciplinary:

- LORET workshop facilitator: 'Did anyone else list other aspects of the problem?'
- Teacher 34: 'Yes, affordability.'
- LORET workshop facilitator, Teacher 36, and Teacher 32: 'Yes.'

→ After this 'confirming move' of the facilitator, the participants continue to elaborate on affordability as an aspect of the sustainability challenge 'sustainable food production and consumption':

- Teacher 34: 'All those [sustainable] products are much more expensive than in the supermarket.'

- Teacher 3: 'Externalisable costs. All those costs of water purification, […] right, are not included in the product. And that is, that is part of what makes it difficult for people to pay more because yes, those other products are cheaper, why would I be the only crazy person to pay more for that.'

[…]

- Teacher 32: 'What then do you do with poorer groups in the population? For them it becomes again much harder and more difficult.'

- Teacher 3: 'Yes, but is it justified to say: no, we are going to keep it affordable for poor people and we are going to give products that are actually not that good.'

- Teacher 32: 'A no, no absolutely not. Absolutely not.'

[…]

- Teacher 3: 'There may also be students here… There are quite a few who are arriving here with a bag of chips [for lunch].'

- Teacher 32: 'Who come here, have no food, empty lunch boxes.' […]

- Teacher 3: 'Yes, yes, yes.'

- LORET workshop facilitator: 'Do you really have that a lot?'

- Teacher 32: 'We have some.'

[…]

- Teacher 36: 'That remains, that remains somewhat hidden'

- Teacher 3: 'That's hidden. That is certainly hidden.'

[…]

- LORET workshop facilitator: 'So we have the tension of affordability. But we were just a while ago also talking about farmers who are in a difficult position economically because we are actually paying less and less for our food.'

→ After this 'generating move' of the facilitator, Teacher 3 raises the discussion to the level of school subjects:

- Teacher 3: 'That is also history right.'

- LORET workshop facilitator: 'Yes, and the whole economic… Yes. But also economics, right. I don't know if there is someone here who teaches economics?'

→ After another 'confirming move' ('Yes') and an 'adding move' of the facilitator ('also economics'), a participant suggests to include an economics teacher in the LORET team:

- Teacher 37, Teacher 32: 'No.'

- Teacher 32: 'I've already thought it would be great if [economics teacher] would join in. Because he was once CEO of [a company] that sells food that is a bit more sustainable.'

→ That teacher joined in during the next meeting.

Another example concerns how the interventions of the workshop facilitator encouraged the participants to move away from providing solutions themselves towards designing lessons that invite students to generate these and, thus, to overcome the disturbance of the habit of 'teaching as lecturing' (see above):

- MOS coach 1: 'In general you can say: with a low ambition we are already working on a perfect biotope for amphibians, and in the meantime, we dream of attracting more and more great crested newts.'

- LORET workshop facilitator: '[…] It was also said: it would be interesting to further investigate that environment between two areas. Is that something where you see opportunities for the students to play a role in that?'

→ This 'reorienting move' of the facilitator does not bring about the intended[8] effect that the participants change focus:

- Teacher: 'Is the aim of the school or of this project to create the best possible biotope or are we really talking about placing that salamander here?'

- MOS coach 1: 'You are not allowed to place it: it is an endangered species. […] So you have to give those species better chances by working on the ecosystem.'

- LORET workshop facilitator: 'Do you see opportunities to investigate this together with children?'

→ After this repeated 'reorienting move', the participants change focus and start to discuss how to involve students in the investigation:

- Principal: 'I certainly think so. We have a lot of children in grade 5 and 6, but also in the younger grades, who find it really challenging to work on that.'

- Partner (landscape architect): 'Maybe we should also take a look at how that salamander from [the nature reserve] comes to us [the school campus], and what route it follows. Perhaps corridors are needed to get here more easily […] I find that fascinating: to take the children for a walk from [the nature reserve] to here through the field, and to say: "Here is a field, that is going to be harder." But I don't know what the preferred way is to get here.'

- LORET workshop facilitator: 'That's interesting to find out together. That's the kind of resources they need. If you prepare lessons like this for the students, that's the kind of resource they need when it comes to the phase of proposing solutions. In order to search for an ideal route, they need as a resource: what kind of route does that salamander prefer, and how can we redesign this route so that there is a better chance that it will find its way.'

→ Here, the facilitator connects the participant's reflections to the overall purpose of the workshop (identifying useful resources for supporting the students in the problem-solving process) and performs a 'specifying move' that deepens the ongoing discussions by encouraging the participants to specify which resources to gather and where to find them:

- MOS coach 2: 'That know-how is present here in the [environmental education centre].'

Tools used in LORET workshops

We observed how the LORET workshops tools helped participants to plan lessons starting from a sustainability challenge instead of from the curriculum as well as to take the students along in a problem-solving process instead of providing them with all answers through lectures. This was the case both in the preparatory assignments and through exercises during workshops.

[8] This can be concluded since we observe the facilitator repeating a reorienting move in her subsequent intervention and, when she notices that it then does have the the effect that the participants change focus she does not perform another remediating action.

We heard, for example, how the assignment to make an inventory of useful resources to support the students' problem-solving process was experienced as helpful for planning lessons in a cross-curricular way:

> *'I found it difficult to fill in that large Excel table and add topics, cross-curricular. To really see it visually, I had never done that before. Usually when we work cross-curricular, we ask 'what do* yòu *teach?' and 'what do* yòu *teach?' and 'what are the interfaces between the two'. But with that table it was really very visual and it was like, ah yes, ok. That was new for me to think about it in that way.' (teacher)*

In the first LORET workshop meeting, we engage participants in the exercise of 'didactical carving' (see further below). The purpose is that teachers first individually brainstorm about locally relevant sustainability problems that are both authentic challenges *and* manageable for the students. Subsequently, they share their suggestions and discuss these with the whole group. The following example illustrates how this supported a teacher in the didactical work to turn the general sustainability issue 'biodiversity' into suitable education content. She 'carved out' a specific challenge in line with the principles of manageability and authenticity: attracting animals that are no longer very common in nature.

> *'I see that biodiversity is very popular with the pre-schoolers, especially attracting animals that are no longer very common in nature. For example, with the frog project at school; we see that the children feel a connection. I think it is also something that children can quickly see the effect of and feel: Ah, I belong to a greater whole. I think if you can tackle that as a small child, that's something that will last forever.'*

In her argumentation, she refers to aspects of manageability such as visibility of effects in the short term (see also below).

Input of content experts

We observed many times how MOS coaches, the environmental education centre or other content experts involved provided input into the LORET workshops that helped participants to overcome a lack of knowledge about the sustainability problem in focus, i.e. about the subject content they would focus on in their teaching.

Here, we present an example of how the environmental education centre provided pilot school 4 with a tailor-made biodiversity analysis of the school's environment in the first LORET workshop which turned out to be very inspiring for the school to select and specify (i.e. to 'carve out') a locally relevant problem for their students to work with and – as we illustrate below – to design lessons that take the students along in a quest for solutions:

> *'With the biodiversity advice at this stage we give the school a framework of what role it can play in relation to biodiversity, linked to provincial policy. The [environmental education centre] is working on nature connections: connecting nature hotspots in Limburg, since populations need much more space. It is very interesting that your school can be a stepping stone on a nearby nature connection, for example for the crested newt: a rare species of salamander. Different policy levels are working on upgrading that landscape there. The city is developing stepping stones for this newt, and that nature*

corridor runs quite close past your school, connecting larger nature centres. The city is very active with that. The question is: what role can your school domain play? It can, because you have different levels of ambition… There is a chance that the salamander will visit your domain. If you prepare for this as a school, so if you develop a biotope for the newt, there is a lot of potential to make it attractive for amphibians. It gives a lot of opportunities. You will increase the nature value of your domain enormously. A water element on your domain offers many opportunities. What else can help to attract that species? Our advice can provide inspiration for the school garden designer. Certain plants have an enormous biodiversity value for the school, for example.'

In pilot school 1, we invited a researcher to give a presentation about sustainability transitions in the agro-food system because the teachers and principal indicated that they were lacking sufficient content knowledge on the chosen topic of sustainable food production and consumption. This was considered helpful both for the teachers' own capacity development and as a source of inspiration for selecting teaching content for their students.

- Interviewer: 'And the presentation of [the researcher], did you have the feeling that that was necessary to get started with LORET or to be able to investigate a problem? To prepare for that actually?'
- Teacher: 'Yes, I thought it was interesting to delve into it a bit at our level. That was certainly interesting. Yes, there are different forms to delve into something, but that was a form that I certainly thought was ok.'

- Interviewer: 'Like you said a moment ago, usually when you work with experts, they also come in the classroom, and then that's not just for you. Maybe that's different with LORET?'
- Teacher: 'Yes, I had that enormously with that workshop or that lecture by [the researcher], yes. I had that enormously. But then I immediately thought: I'm going to ask her for those slides so that I can show that to the children right away. […] But not necessarily everything. I know there are some shocking numbers in there and sometimes for those kids that can be a bit…'

The environmental education centre as well as the MOS coaches involved in the workshops offered the teachers numerous suggestions and recommendations ranging from existing projects and teaching materials, possible partners, material and financial resources, theoretical concepts, etc. Some examples:

'What I certainly wanted to offer [to the school] are things from the PNC [environmental education centre]. We currently have a bee project running, and that is: for a whole school year - in a narrative design aimed at children in the third grade. The children become bee-wise. So, they learn about the bee, and they also take bee-friendly measures at school. One element of this process is also a workshop, which we fund, and then a bee expert comes to school and helps you: do you want to make a bee hotel? Do you want to make a sandhill for soil-dwelling bees? Do you want to plant a bee tree? We also have a brand-new bee game. We also want to help you with the search for research materials. We have the know-how about good magnifying glasses, search maps, apps, wildlife cameras which you can borrow for free. We can also give you a budget for this, if you want to buy research material. That is a support we gladly offer. We also have an in-service training day for teachers about wild bees and the educational added value that I as a MOS coach can give. We also have a comic strip about Suske & Wiske, which we can distribute, and that strip is about an ecoduct, "The beastly bridge". That is about connecting nature. So that could fit into the exploration phase.'

'An interesting concept that can help [for the lesson planning] is the idea of the 'black box'. We once included that in a thematic manual about water from MOS, a long time ago. The principle is that you can view the school as a black box and you must ensure that there is as little influx of water possible. So, decreasing the demand. And then you have to make sure that you keep that water in the school as long as possible and then that goes, that could go on, for example, by thinking about a green roof, for example, to buffer that capacity. And finally, to ensure that the outflow of the water is as clean as possible. That is more about the pollution. But then you see the water problem as a slightly larger, slightly larger whole. I'm going to look that up, I'm going to send that to you.'[9]

'When you talk about partners, I hear a lot of local [food] producers already mentioned. But what I haven't really heard yet, there are also organisations that have also published a lot of studies and so on for schools. Just think of [NGO] Rikolto and their possible partners. I've not yet heard this here. We can also gain insight and increase our knowledge from partners who are also involved in schools.'

'Are you aware of the learning line on nutrition "healthy life" that exists? I think this could be very interesting for this project if I hear you talking about making links with which grades, with which subjects… That is a PDF that you can find online, from the Flemish Institute for a Healthy Life with a lot of links and where you can connect it to the attainment targets… So basically, I think you will find a large part of the work that needs to be done in there.'

Input of school coaches

Also the input of people that are involved in coaching schools proved to be helpful for overcoming problematic situations related to establishing LORET-based open schooling practices. In this case, we observed the impact of the MOS coaches involved in the LORET workshops but we believe that similar input can come from pedagogical advisors or other types of coaches. They can draw on earlier experiences with other schools in order to help the participants to tackle specific didactic challenges.

One way in which we observed them doing so, is by sharing exemplary practices from other schools. In pilot school 4, for instance, the teachers did not easily identify resources to guide their students through the fourth phase of the problem-solving cycle: evaluating the problem-solving[10]. This gap was filled by a MOS coach who provided several possibilities among which the following example that he observed at another school he coaches:

'[The 'Safari case'] is a suitcase with research materials: plant pots, fish nets, field guides, etc. I know the term and its application from school [X]. They also have a specific way of working with this, namely: this is independent work for students in the second grade[11]*. So, on a regular basis, the children are allowed to go out onto the playground with a small group and explore the biodiversity there. This is accompanied by a kind of manual/approach on how to go on a somewhat standardised 'safari' and*

[9] As we will explain below, this concept has been taken up by the teachers to plan their lessons.

[10] See above: we repeatedly noticed how teachers can struggle with this and related it to the disturbance of the habit of 'teaching as lecturing'.

[11] Year 3-4 of primary education, students aged approx. 8-10.

explore the biodiversity. That also makes it possible to describe the evolution of it. I heard that the pupils then got a good knowledge of nature.'

We also saw coaches recommending specific teaching materials based on their experience with and judgement of its quality. In a preparatory assignment for a LORET workshop in pilot school 4, the MOS coaches suggested a lot of teaching materials that could be used as resources for the students' problem-solving process. During the workshop they also indicated their judgement of the quality of the materials, e.g. recommending the 'Living Planet School' teaching materials provided by WWF as 'highly qualitative and useful'.

Furthermore, and particularly relevant in relation to teachers' struggle with using real-world problems instead of the curriculum as a driver for lesson planning, we saw coaches illuminating links between working with sustainability issues and realising curriculum goals:

'What always surprises me personally is how many physical education attainment targets can be met by having the children do nature management, for example. And then I realise: Physical education is not just that subject. Physical education must be seen in a broader sense. So, depending on which activity you actually do, you can also realise attainment targets.'

School policies

Repeatedly, we observed in workshops and meetings how school-specific policies were helpful to overcome or avoid problematic situations related to how LORET can disturb teaching habits and customs. One way in which this can be the case, is by the existence or establishment of 'niche practices' such as atypical school subjects or opting to invest extra hours in project-based teaching. This helps, for instance, to make it easier to use real-world problems rather than the curriculum as a starting point for planning lessons.

'We have what is called "studio time". Every class has studios twice a week in the afternoon, where they do technique studios or vegetable garden studios. Within that studio time, they can also work a lot on this [LORET] project. And one of the children has been able to develop his own project during "flourishing time" - that's another subject we have. One of the pupils here has built a hedgehog hibernation place. In "blossom-time" goals from all domains and all subjects are addressed, but that is more of a project that the children set up themselves: what can I flourish and/or grow in?'

'The teacher who takes the lead on the LORET-trajectory in the pilot school suggests to choose one subject that takes on a pivotal role in the LORET-plan and complements this with additional lessons of other subjects. Most schools in Flanders are still subject-oriented but now and then cross-curricular initiatives rise up like STEM education, project-based education (PAV: 'Project Algemene Vakken'), research competences, subjects on citizenship and from September 2021, all catholic schools introduce a school subject named 'social, economic and artistic education'. These more cross-curricular oriented subjects can play a leading role within LORET. Preferably this LORET-leading subject is taught at least two hours a week and is compulsory so that the whole class can take part in every phase of the problem-solving process. [...] The teacher of this LORET-leading subject supports his/her colleagues because s/he can keep a close eye on the implementation of the LORET plan and mobilise relevant knowledge and skills offered by the other subjects.' (excerpt from field notes)

Another important way in which school policies can help to overcome or avoid problematic situations, is flexibility of the school management. This is vital, for example, to help teachers to manage the workload, avoid schedule conflicts, etc.

> *'The principal of the pilot school showed explicit openness for 'being creative' with rules in order to encourage cross-curricular education. He suggested to remove some teaching content and replace it by lessons focussed on the 'key competences'. He also referred to the need and possibility (e.g. through adapting lesson schedules) to tackle timing issues caused by the traditional way of organising teaching in 50 minutes time slots.' (excerpt from field notes)*

> *'The principal seems to be willing to explore opportunities to organise future teaching schedules in such a way that teachers who are motivated to work with LORET can teach in subjects and classes involved in the LORET plan.' (excerpt from field notes)*

The principal of one of the pilot schools also told us about her efforts to select a specific team of teachers who are willing and able to teach in a way that fits the school's vision in which, she believes, LORET fits in very well.

> *- Principal: 'In the process of building the school and legislation that comes with it, forming the teachers' team was the hardest part. I had a staff change of seven out of ten people in the first four months of last year.'*
> *- LORET workshop facilitator: 'Why?'*
> *- Principal: 'The school is called "Straal" ["Shine"] and those people were not shining. They came to do their job and were not open to connect with children in that way. They were afraid to teach together with another teacher. Because we work with community groups ['leefgroepen'] with two or three teachers per community group helping each other, giving and receiving feedback. I have had coaching conversations with them and then teachers stated: "I am doing my job, aren't I?" Straal is my fourth child; and as a principal I follow my guts. I started this as a dream: things can be different for the children. And my children always come first. My teachers' team is number 2. I want them to feel good, but they have to shine so that the children can shine. That's why a few dropped out at the time. But now, after the whole selection procedure, I have a very nice team. I always ask the teacher: what do you like to do? What is your hobby in your work? For example, I have a wonderful nature kindergarten teacher, and she has a talent for cooking and she does the cooking studios with vegetables from the vegetable garden, where children also think about vegan food, etc. I also have other teachers who teach music or crafts, and I can see those are recharging moments for them. You need that variety. My people are also just more creative and open-minded. And I want to listen to what they like to do. I am very happy with the team now. It is a second home for many. I have done 218 job interviews. We had sent leaflets around [the city] and there were also vacancies on the school website. There are not many people who fit in here.'*

She also explained that they attract a somewhat specific public of students and parents.

> *'Your presentation fits in so well with our vision. [...] [We attract] especially people who are "in a quest". Who are feeling: My child sitting at a school desk all day, not being able to go outside... People that say: My child likes to be outside; the playtimes are too short; my child has other talents. Many people said these kinds of things during the enrolment and visitation moments. We attract people from all over*

the city. People who are concerned about the environment, who come with a cargo bicycle to school. People who really choose for sustainability. We also have people who choose for our vision.'

Partnerships

Finally, and vital in the context of open schooling, we observed how collaboration and partnerships repeatedly emerged as a way to overcome problematic situations. In the following example, a MOS coach raises some recommendations in response to a teacher's concern for extra work load:

> *'Make use of the people who could support you; as a teacher you don't have to do it all by yourself. It is therefore a very good idea to look at: do we have parents? But also from the [environmental education centre] or from another angle, you could call in help; for example, a bee or nature expert.'*

We also noticed that *local* partnerships, input from local partners, were in particular seen as a solution:

> *- MOS-coach: 'So you can look at the human capital in your local network: who has know-how about biodiversity? [...] To what extent is there already a culture of environmental walks – going out to discover?'*
> *- Principal: 'The pre-schoolers go on environmental walks every Wednesday morning. The primary classes have the option of going on a walk every Tuesday afternoon.'*
> *- MOS coach: 'What do you think about the suggestion of a guided walk in the school environment, with a nature guide/neighbour? And also a separate walk for the teachers as part of an in-service training day to get to know the natural school environment better.'*
> *- Principal: 'I think that's very cool. Definitely.'*
> *- MOS coach: 'I included that suggestion because I've noticed that in the past, the teacher was often from the village, but nowadays that's not so common anymore. So, teachers often don't know the school environment very well. And then organising a guided walk is an added value.'*
> *- Non-school partner: 'Indeed, to get to know more places in the area.'*
> *- Principal: 'Most teachers are not from the neighbourhood. We have two out of twelve teachers who live in the neighbourhood [...] at a cycling distance.'*

Conclusion

We identified different ways in which participants of the open schooling partnership were able to overcome or avoid disturbances of habitual manners of teaching and of the established routines in school (teams). A summary:

Overcoming disturbances of teaching habits and customs
Teachers learning from each other
Interventions of LORET workshop facilitators
Tools used in LORET workshops
Input of content experts
Input of school coaches
School policies
Partnerships

Upscaling and sustaining impact

With our assessment, we also aimed to investigate what is needed to upscale the pilot experiments' impact beyond only those actors directly involved in them as well as to sustain the impact beyond the three-year lifespan of the SEAS project. In particular, we aimed to gain insight into what is needed to optimally **enable teachers and partners across different schools to learn from and inspire each other** as well as what is needed to optimally **equip intermediary actors to support teachers, schools and partners** in designing and implementing high-quality open schooling about sustainability problems. We focus on the role that the **SEAS library** of lesson plans and teaching materials can play in this regard. As mentioned, EduQuality has the task to build the infrastructure for digital libraries as well as to develop a business plan for how to sustain the impact of SEAS and the Belgian local network served as a pilot case for that.

External analysis of opportunities and threats

Exploratory in-depth interviews with seven teacher (trainer)s and a survey for teachers (n=79) (Van Vooren 2021) complemented by an analysis of field notes and transcripts of meetings in the Belgian SEAS network and interviews with the actors involved in it, resulted in identifying the following threats and opportunities in the Belgian 'market', i.e. the target audience for upscaling and sustaining the impact of open schooling initiatives:

Opportunities:

- Teachers' willingness to and experience with **sharing** lesson plans and teaching materials: 92,3% of the survey respondents already share lesson plans and teaching materials (95,8% of them in their own school, 27,8% on public platforms).
- Teachers' interest in **inspiring** lesson plans and teaching materials: 43 out of 79 survey respondents indicate that they want to inspire and be inspired.

  'I am always looking for inspiration for activating forms of teaching.'

- Teachers' desire to **save time**: 26 out of 79 respondents indicate that they share materials to save time; 16 out of 79 respondents indicate that they share materials for efficacy reasons (win-win situation, not reinventing the wheel).
- Teachers' need for support in aligning their lesson plans and teaching materials to the **new attainment targets** as something for which the SEAS library could offer opportunities: 20 out of 79 respondents indicated that they would want to do that.
- Teachers' need to connect with colleagues and form a **community** of practitioners that learn from, inspire and help each other: 40 out of 79 respondents indicate that they feel enthusiastic

to share materials when they are helping others with it; a strong[12] significant correlation exists between the willingness to share materials and wanting to collaborate with other teachers.

- Teachers' willingness to give each other **feedback**.

  'Giving feedback [...] is okay with me. I often make use of it. It is important that this benefits the quality.'

- Teachers' **motivations** for creating and sharing lesson plans and teaching materials: 40 out of 79 respondents indicate that they are sharing materials out of collegiality.

  'Teachers need a certain motivation to share lesson designs. My colleague's motivation was perhaps the idea of being a pioneer.'

  Asked about what would motivate the respondents to engage more strongly in uploading, downloading, and reviewing lesson plans and teaching materials, they mainly mentioned aspects that reflect an *intrinsic* motivation. These are the three most mention motivations to
  - upload: to help others, getting acknowledgement, co-creating with a colleague and getting feedback from other teachers;
  - download: useful material, learning something new, high-quality material, saving time;
  - review: help each other, collaborate, get feedback in return.

- Teachers' desire for sharing and dissemination channels **driven by the profession**.

  'I want a free and independent platform.'

  'Away with being tied to publishers. Through such a database you can "compose" your own school year.'

- Potential **collaboration with other platforms** such as KlasCement, Scientix, etc.: 65,4% of the respondents are using KlasCement, of which 46,2% mainly to download, 3,8% mainly to upload, 15,4% both as a downloader and uploader.

Threats:

- Teachers' reasons for **not wanting to share** their lesson plans and teaching materials.

  'I don't know where to share the materials.'

  'Teachers want positive reactions and if they don't have that, they feel a bit insecure.'

  'I think my work is not good enough.'

  'I'm afraid that I'm not respecting the copy rights.'

  'I'm afraid for the criticism.'

[12] With the result of the two-tailed test <.001

- Teachers' experience of a lack of **compensation and/or acknowledgement**: 30 out of 79 respondents indicate that they want acknowledgement for their self-created materials; 4 respondents mention that they would like a system for copyrights.

  'When I share materials, I don't get anything in return and that's not fair.'

  'I don't want others to use my materials without getting copyrights.'

- Teachers' reasons for **not wanting to use** others' lesson plans and teaching materials: only 9% of the respondents indicate that they use ready-made lesson plans.

  'I only want to use my own materials adapted to a unique situation.'

- Teachers' concerns regarding the **quality and findability** of materials: 42,7% of the respondents is not finding reliable sources while preparing their lessons; 52% indicate that making choices between all available materials while preparing their lessons is difficult.

  'I prefer not to put homemade lessons online when I know it will still change or when I am still thinking about things, because this seems uncomfortable for the other teachers.'

  'Important, I think, is a reward for a commitment such as improving the quality of existing material.'

- The extent to which teachers do not create their own lesson plans and teaching materials but rely on **textbooks**: 84,6% of the respondents uses an existing textbook as a basis for their lesson plans; nobody uses 100% prefab materials.

- Uncertainty regarding who will be willing and able to conduct **reviews** and engage in **quality care**: survey respondents' motivation for in-depth evaluation of lesson plans and teaching materials is generally lower than for sharing and using materials[13].

  'We [MOS coordinators] don't have time in our planning and goals to do the quality check and refinement.'

  '[One of our school coaches says] that the assignments are not submitted, let alone the feedback on those assignments that she invites teachers to send. She has a very difficult time with that and can't figure out how to tackle it. It is very difficult to make teachers submit it, so you have to create something that goes beyond classroom practice, there has to be something that makes them want to do that.'

- **Path dependency** of existing sharing platforms: KlasCement is an existing Flemish sharing platform that has gathered 278.656 users and collected 72.165 teaching materials[14]. It is very popular and some partners are reluctant to create something new.

  'We have to use KlasCement for this. […] For me it is obvious that we don't want to create something new.'

[13] When asked what would motivate them to engage in quality care, teachers mentioned 'working closely together with a professional colleague', 'receiving feedback on my teaching materials in return', and 'helping others' as the main motivations.

[14] Figures December 2021.

On the other hand, some disadvantages have been mentioned, e.g. a limited focus on quality care and concerns about findability of useful materials: 29 out of the 58 survey respondents that use KlasCement indicate that they are losing time while looking for useful and high-quality materials on this website.

> *'By the time you find something useful in the more than 60.000 materials you could as well have made your own course materials.'*
>
> *'It is true that it is not used a lot to score or comment. They want to stimulate to make more peer-reviews.'*

It is unclear to what extent adjustments can be made to the existing platform and/or whether the SEAS database could be integrated in KlasCement or added as an entry.

> *'What you aim to do in SEAS is extremely ambitious. Especially the quality care. Our main concern is how to increase the amount of useful content for teachers.' (KlasCement's head of user experience)*

Summary

Opportunities	Threats
Willingness to / experience with sharing	Not wanting to share
Interest in inspiration	Lack of compensation and/or acknowledgement
Desire to save time	Not wanting to use others' lessons
New attainment targets	Concerns regarding quality and findability
Need for collegial community	Relying on textbooks
Willingness to give feedback	Uncertainty regarding reviews / quality care
Motivations for sharing	Path dependency existing sharing platforms
Desire for channels driven by the profession	
Potential collaboration with other platforms	

Internal analysis of strengths and weaknesses

We identified strengths and weaknesses of the open schooling partnership, the actors involved, and the employed methods and tools in view of upscaling and sustaining impact through 1) our analysis of documents, field notes, interviews (partly also from Van Vooren 2021), and transcripts of meetings, and 2) several reflection workshops by UGent researcher Katrien Van Poeck and EduQuality founder Leif Östman on how the open schooling partnership can be assessed in relation to the above elaborated external analysis. The following strengths and weaknesses emerged from this analysis:

Strengths:

- The **availability of strong, useful, diverse, and complementary expertise** in the open schooling partnership[15]:

[15] The value of this has also become evident in our analysis of how to overcome disturbances of teaching habits and customs: see above.

  - Researchers with pedagogical/didactic expertise (incl. in sustainability education and open schooling) and experience in crossing boundaries between theory and practice (e.g. action research through co-creation in pilot studies).
  - Partners with useful content expertise: MOS coaches, environmental education centre, Flemish government's Department of Environment, etc.
  - Partners with decades of experience in coaching schools on sustainability education: MOS coaches, environmental education centre.
  - Teachers and principals with proven practical experience.
  - EduQuality with experience in developing tools and processes for the co-creation, sharing, and quality refinement of lesson plans and teaching materials.

- The developed SEAS library to share lesson plans and teaching materials as a potential vehicle for quality care and for avoiding to re-invent the wheel over and over again and, thus, to save time.

- The experience and tools to conduct (LORET) workshops[16] where didactic researchers, content experts, teachers, and partners collaborate to co-create lessons and teaching materials as a driver for quality care, for 'feeding' the library with useful and high-quality materials, and for the development of a collegial community that can empower and inspire teachers.

- A set of strong, shared values in the partnership that, according to the external analysis, aligns with the values and needs of the potential users:
  - Striving for better education and a more sustainable world.
  - Striving to empower and support the professional community of teachers based on mutual respect for complementary, unique forms of expertise and experience.
  - Striving for quality and efficiency: supporting teachers to avoid re-inventing the wheel, building on each other's work and, thus, continuously refining quality *and* saving time; expanding impact and benefits beyond those directly involved in activities.
  - Education as a common good: striving for mission-oriented collaboration driven by the profession, not by commercial interests, and resulting in open access lesson plans and teaching materials.
  - Fair acknowledgment of all partners' contributions.

- Contacts and connections with potential – national and international – partners that can contribute to further expanding and strengthening the partnership in the future. For example:

  'To combine this with some teacher training institutions. To work together with teachers who work already with this. We can give some names of people who are asking help on this topic.'

[16] See also below: 'Updating and differentiating SEAS concepts, tools, and methods' – 'Co-design for social innovation': Lesson Design Workshops.

'Who else is important here? NGO's like Djapo, or Kruit. Organisations that already make efforts in capacity building with a focus on pedagogical and didactical knowledge. We should map the possible stakeholders.'

- EduQuality representative: 'It might be interesting to talk to KlasCement. How do we see if we can implement things in KlasCement? How can we create a synergy-effect that we are offering something for them as well? […]'
- MOS coordinator: 'We have already a good relationship with people working for KlasCement. […] We could arrange a meeting.'

'Did you have contact as well with VLEVA for green Erasmus? This is directed towards Educational institutions. They will use Erasmus resources to implement the Green Deal in education. They are looking for collaborations on environmental topics. It may be interesting to get in contact with them'.

- Concrete methods and tools – some existing, some in-the-making, some as ideas to be further developed – that complement each other in an overall quality refinement system:
  - To secure an increased quality of materials uploaded to the library: activities such as Lesson Design Workshops (see below) and tools such as digital lesson planning tools with research-based guidance for teachers.
  - To facilitate continuous improvement and refinement of uploaded lesson plans and teaching materials: an automatic referencing system for tracing how users build on and adjust each other's work (e.g. to contextualise it to diverse settings, to update it), protocols for reviews by teachers, protocols for reviews by researchers.

Weaknesses:

- Technical costs of the digital library: security, adding users, technical support, data storage, future investments to add more functions, etc.

- Costs for developing and offering activities and tools to increase the quality of materials uploaded to the library (see above: Lesson Design Workshops, digital planning tools)

- SEAS project's limited duration resulting in several uncertainties for the future:
  - Uncertainty about who will finance the remaining technical costs (maintenance, storage, security, further development, etc.) after the termination of the SEAS project.
  - Uncertainty about who will manage the partnership and how after the termination of the SEAS project.
  - Uncertainty about who will (further develop and) perform LORET / Lesson Design Workshops after the termination of the SEAS project.
  - Uncertainty about who will conduct quality reviews after the termination of the SEAS project.

'How do we keep it a living community. To keep the fire hot? It is a pity when it is a dead born child. Quality care by experts, who will do this? Who will promote it? Who will make it a living community?'

- Challenges regarding how to practically link the national and international library due to different languages, differences in the specific educational contexts, etc.

'We need to make [the library] at an international AND national level. It needs to be contextualised to each country.'

'Will all lesson plans be published in English?'

Summary

Strengths	Weaknesses
Availability of strong, useful, diverse, and complementary expertise	Technical costs of the digital library
SEAS library of lesson plans and teaching materials	Costs for activities/tools to increase the quality of materials uploaded to the library
Workshops where didactic researchers, content experts, teachers, and partners collaborate	SEAS project's limited duration resulting in uncertainties for the future
Shared values aligned with potential users' values	Challenges regarding how to practically link the national and international library
Contacts and connections with potential partners	
Methods and tools for quality refinement system	

SWOT analysis: strategies for upscaling and sustaining impact

In this section, we confront the internal analysis (Strengths and Weaknesses) with the external analysis (Opportunities and Threats) in order to formulate possible **strategies for the SEAS library to contribute to upscaling and sustaining the impact of the Belgian open schooling pilot experiments**. We formulate a set of **key principles** which we develop further below (see 'Updating and differentiating SEAS concepts, tools, and methods' – 'SEAS library'). These principles have also been validated in other contexts through the network of EduQuality and can therefore also be helpful when establishing libraries in other SEAS countries and beyond.

- **Prioritising the quality of lesson plans and teaching materials over the quantity of uploaded contributions** = using the partnership's and the SEAS library's strengths to meet users' concerns for quality, findability, and usefulness. In a mapping of existing libraries by EduQuality as well as in communication with organisations that run libraries, it is obvious that many existing ones are driven by quantity: the general idea is that of a correlation between quantity of materials and users[17]. However, this approach does not take into account the time consumption of finding useful, reliable and high-quality materials (see above).

- **Using (LORET) lesson design workshops and other 'maker spaces' where teachers, content experts and didactic experts co-create lesson plans and teaching materials as a quality care tool prior to uploading** = using the partnership's strengths and experience to meet demands for a strong collegial community and realise efficacy and efficiency gains by combining strong digital tools with activities that foster a vibrant community.

[17] See for example above: KlasCement's head of user experience's statement that their 'main concern is how to increase the amount of useful content for teachers'.

- Organising the SEAS library as a vehicle for commons-oriented peer-to-peer production = realising the partnership's shared values in practice, meeting the demand for channels driven by the profession, and building on existing motivation. The P2P Foundation describes this as follows:

  'P2P is an abbreviation of "peer to peer", sometimes also described as "person to person" or "people to people". The essence of P2P is this direct relationship, and its core characteristics include:
  - *Creation of common goods through open, participatory production and governance processes*
  - *Universal access guaranteed through licenses such as Creative Commons, GPL, Peer Production Licence.*

  P2P is a process or dynamic that can be found in many communities and movements self-organising around the co-creation of culture and knowledge. Well known general examples include the free/open-source software movement; free culture; open hardware; and open access in education and science.' (https://p2pfoundation.net/the-p2p-foundation/about-the-p2p-foundation)

- Focusing the efforts on attracting, supporting and empowering a specific segment (niche) of possible users: those who are willing and able to create and share high-quality lesson plans and teaching materials (active 'uploaders') = avoiding external weaknesses (some teachers' reluctance to share, relying on textbooks, etc.) and optimally using strengths (some teachers' intrinsic motivation, desire to connect with colleagues, etc.) of the target group.

- Creating a common marketing and communication strategy to attract 'downloaders' and to encourage them to engage in quality care through giving feedback and uploading variants of downloaded lesson plans and teaching materials = using strengths of the partnership (e.g. quality care, contacts) to downplay external threats (e.g. reluctance to share/use, concerns for quality and findability).

- Finding ways to continue the work done by the temporal SEAS partnership after the termination of the project = using the available expertise and experiences, connections and contacts, and shared values to create a sustainable collaboration and partnership.

- Finding (additional) partners willing and able to share/finance the costs for continued work = using connections, shared values, and distributed contributions as a way to avoid financial uncertainties.

- Developing a fair system for acknowledging and compensating contributions = reducing reluctance to share lesson plans and teaching materials and strengthening/empowering a collegial community.

Synthesis of findings

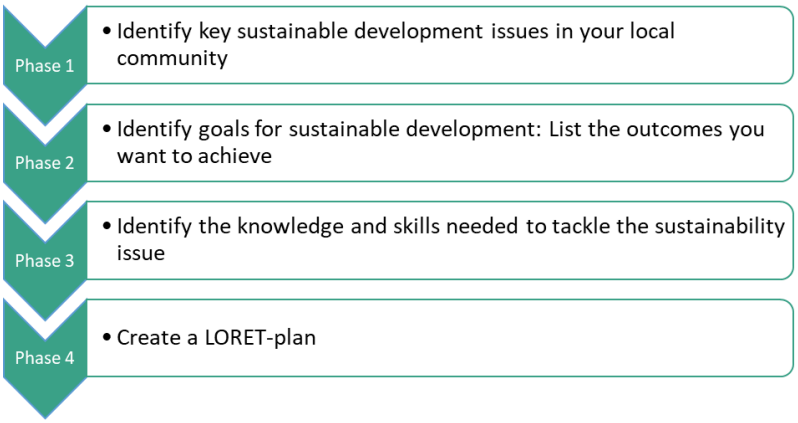
Updating and differentiating SEAS concepts, tools, and methods

In this section, we explain how our findings contribute to updating and further developing SEAS concepts, tools and methods.

The LORET tool – Locally Relevant Teaching

The work in the pilot schools that implemented LORET-based open schooling and our analyses of these cases (see above) resulted in a number of important adjustments to the LORET tool: a new trajectory, aiding tools and materials. As we described in D3.1, the adaptation and fine-tuning of LORET already started from the start of the local network activities on and was done in close collaboration with LORET developer Leif Östman. The results, which have been validated in other contexts, have been added to the LORET homepage, which is an open-source and run by EduQuality.

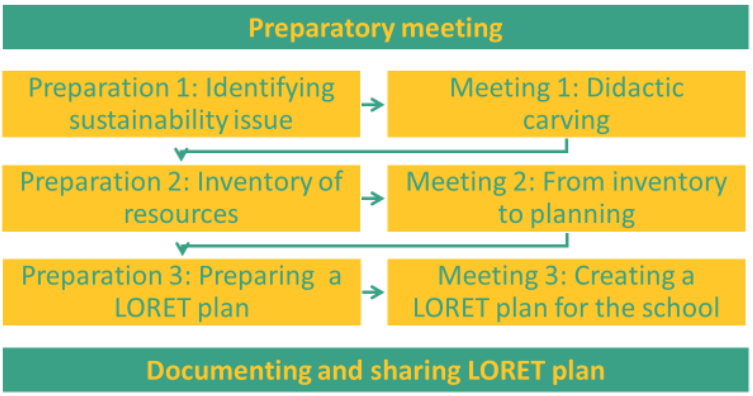
The initial LORET trajectory (Östman et al. 2013) looked as follows:



The following findings and considerations resulted in a transformation of the LORET trajectory:

- the need to add a preparatory meeting to discuss practicalities, grasp the school-specific needs and expectations, etc.
- the need to frame LORET more sharply as a planning tool for teachers to plan their lessons;
- the need to provide a sharper didactical focus;
- the need to give participants time to do some preparatory work so that the work during the sessions can be done more efficiently;
- the need to balance, on the one hand, a clear and systematic way of working with, on the other hand, flexible adaptation to the specific school context.

The result was the following revised trajectory:



The work of identifying and selecting a locally relevant sustainability problem (former Phase 1) is now done in preparatory assignment 1 and meeting 1. The aim of strengthening LORET as a tool for offering teachers *didactical* support is reflected in the approach to this assignment and meeting. We invite teachers to turn major, societal sustainability problems into *educational content* through what we have called 'didactical carving' (Van Poeck and Östman 2020). This means 'carving out' of the often comprehensive, complex and overwhelming sustainability problems a problem that can offer the students unique educative opportunities. We operationalised this by offering the teachers a tool for didactical carving based on two criteria (scales):

1. Offering the students a problem that is manageable and susceptible for them, i.e. they are able to grasp it and can influence how to tackle it in one way or another.

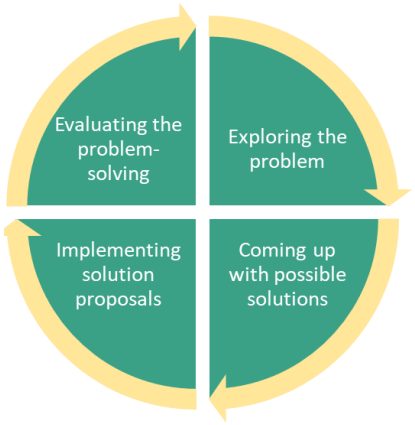
A manageable challenge						
The problem is way too difficult for the students to understand	1	2	3	4	5	The students have sufficient knowledge, insight and intellectual capacities to be able to understand the problem
The students/school do not have access to information, actors, decision making forums, etc. that are vital for tackling the problem	1	2	3	4	5	The students/school have access to information, actors, decision making forums, etc. that are vital for tackling the problem
The students do not have any possibility to influence actions and decision-making in view of tackling the problem	1	2	3	4	5	The students can influence actions and decision-making in view of tackling the problem: ☐ *Directly* (e.g. implementing practical solutions, realising changes) ☐ *Indirectly* (e.g. through trying to influence policymaking by letters, petitions, negotiating, lobbying)
It will take a very long time before the results of students' inquiry and/or actions become visible	1	2	3	4	5	The results of students' inquiry and/or actions will become visible in the short term

2. Offering the students a challenge that has the potential to take them along in an authentic problem-solving process.

An authentic challenge						
The solution for the problem is already available, it just needs to be implemented	1	2	3	4	5	There are no ready-made solutions that can be easily applied to tackle the problem
As a teacher, I already know how to solve the problem	1	2	3	4	5	For me as a teacher, trying to solve the problem would require further inquiry and experimentation

There is one 'right' answer on how to solve the problem	1	2	3	4	5	Trying to solve the problem can be done in different ways that need to be further explored and compared
Solutions for similar problems have already been found in other contexts and can be easily applied here and now	1	2	3	4	5	Although solutions for similar problems have already been found in other contexts, there are no ready-made answers on whether and how these might be applied in the specific local context of the school

These scales are used in the first LORET exercise where we explain the philosophy behind it, present the scales, illustrate them with an example and invite the participants to, first, brainstorm individually about possible suitable challenges and, then, discuss the results in group by assessing each proposal with the help of the scales.



After this step, we move on to the **didactical task of selecting suitable teaching content** by inviting the teachers to **identify resources – in the curriculum of school subjects, in the local environment, in the local community, etc. – that can fruitfully support the students in addressing the locally relevant sustainability problem** (preparatory assignment 2 + meeting 2). While mapping what the curriculum has to offer, we encourage the teachers to explore the wide variety of school subjects as well as to not limit the attention to theoretical knowledge and insights but to also include practical skills, communication skills, inquiry skills, attitudinal aspects, ethical and democratic competences, etc. A mapping of what the school environment has to offer can include people, organisations, physical places, etc. We also encourage them to look for resources in the media, literature, etc. The model of a sustainability problem-solving cycle (see also above) was introduced to support the teacher to identify and select resources that can help their students throughout the whole process of problem-solving.

Teachers are asked to identify various resources for each phase through the following template:

	PROBLEM SOLVING ACTIVITY			
	Exploring the problem	Coming up with possible solutions	Implementing solution proposals	Evaluating the problem-solving
Subject matter in subject A				
Subject matter in subject B				
Subject matter in subject C				
Resources in the school				
Resources in the local				

environment (e.g. places, infrastructure, information)				
Resources in the local community (e.g. experts, networks, organisations)				
Other (e.g. media, literature)				

In the first annual local assessment report D3.1, we described how the third preparatory assignment and meeting are devoted to creating a LORET-plan by identifying connections to curriculum goals; determining the number of lessons that will be needed and the content for each lesson; identifying suitable teaching methods and activities, incl. how students can gather information and take action in the local community; and deciding how to organise the lessons so that the students can effectively integrate the knowledge from the different school subjects. Further experimentation in the pilot schools reported on in the present report resulted in splitting-up the making of the LORET plan in two parts, i.e. two workshop meetings each of them preceded by a preparatory assignment. After introducing the model of the problem-solving cycle, it appeared to be difficult/impossible to plan the whole series of LORET lessons from the start as, at that point, it is not yet possible to know which solution proposals the students will generate and hence to prepare lessons that can support them in that endeavour. The following excerpt from an interview with a teacher of pilot school 1 illustrates this:

> *- Interviewer: 'Now if you go back to such a moment that you think of, that was a difficult moment. That could be a relationship with someone, or it could be something else substantively.'*
> *- Teacher: 'Yes, every time I thought like, phew, when are we going to do that actually? That's so far away. Why do we have to start planning this now?'*

Based on the pilots, we thus learned that it is impossible for the teachers to plan in sufficient detail the lessons that will take place after the students have identified and selected a solution for the locally relevant sustainability challenge that they will implement. Therefore, the later lessons focused on implementing solution proposals and evaluating the problem-solving will be planned through a fourth assignment and workshop meeting that take place after the actual implementation of the lessons/activities and is aimed at exploring the problem, generating possible solutions and selecting a solution proposal to experiment with. Thus, we split the creation of a LORET plan in two parts, corresponding with the first and last two phases of the problem-solving cycle.

Furthermore, we learned that a **final meeting ('looking back and ahead')**, preceded by a **last assignment ('documenting the LORET work')**, is needed after the implementation of all lessons. This is important so as to provide the participants with opportunities to share experiences and reflections, celebrate joint achievements, discuss whether/how the LORET trajectory requires follow-up in the future (with the same or other students), and to take better care of the documentation of LORET plans, lesson plans, and teaching materials. The latter is important in view of **securing the publication of high-quality output (lesson plans and teaching materials) in the SEAS library** (see above). As our analysis of the disturbances of teaching habits and customs reveals, LORET-based open schooling is very new and unfamiliar for most teachers. The teachers that are intensively supported by researchers, MOS coaches, and the environmental education centre PNC in the SEAS open schooling network are doing **pioneering work**. In order to **upscale the impact** of the investments (time, resources, etc.) that helped facilitate this, it is important that LORET lesson plans and teaching materials are shared in the SEAS library in such a way that it can be read and used by other teachers. The last assignment and workshop meeting are designed in view of supporting and encouraging teachers to walk this 'extra mile' so that other teachers that might not see themselves as 'frontrunners' can draw inspiration from these inspiring examples – and eventually contribute to the refinement of it.

The **LORET trajectory** now looks as follows with 5 workshop meetings (2-3 hours) preceded by a preparatory assignment:

Preparatory assignments	Workshop meetings
A1: Identifying locally relevant sustainable development issues	W1: Turning sustainability problems into educational content – didactical carving
A2: Identifying fruitful resources for supporting the students' inquiry	W2: From inventory to planning
A3: Preparing a LORET plan – Part I	W3: Creating a LORET plan – Part I
A4: Preparing a LORET plan – Part II	W4: Creating a LORET plan – Part II
A5: Documenting the LORET work	W5: Looking back and looking ahead

The LORET tool is described on the website https://loret.se/. The workshop powerpoints, preparatory assignments, templates of LORET plans, information letter, etc. are adapted to this revised trajectory and methodology in close collaboration with EduQuality. All this provides a **solid foundation for a training for trainers for future LORET workshop facilitators** in Spring 2022.

Co-design for social innovation

We addressed the SEAS concept 'Co-design for social innovation' with a focus on **co-designing locally relevant teaching**. The LORET workshops are a type of '**Lesson Design Workshops**' (LDW – see https://www.edu.uu.se/research/curriculumstudies/teplab/Collaboration/). This is a specific method for creating lesson plans and teaching materials in cooperation between researchers and teachers that is built upon four principles:

1. LDWs are set up as a genuine co-production between didactic researchers and teachers, each contributing with unique but complementary competences. Thus, the outcomes – the products – are a result of a fusion of didactic research expertise and proven professional experience.
2. LDWs start from a teaching challenge, a teaching task that needs further attention in order to make students learn more and better. Thus, the workshops focus on a professional challenge.
3. The outputs of LDWs are useful products for teachers, such as teaching plans and teaching materials, which the teacher can take home after the workshop and share with colleagues.
4. LDWs are part of a cyclical process of continuous refinement. Instead of reinventing the wheel, we co-create lessons building on earlier work and disseminate these through digital infrastructures that facilitate further feedback and refinement by other teachers. This way the process of quality care and refinement is continued after the workshop.

Our analyses described above have progressed our insights into how a co-design process in open schooling partnerships can be optimally supported. A summary of the lessons learned:

- In the LORET workshops, the co-production (principle 1) did not only involve didactic researchers and teachers but also other partners such as MOS coaches and staff from an environmental education centre. This has proven to be very valuable for bringing another, content-focused form of expertise to the table, e.g. knowledge on sustainability problems or on interesting resources in the schools' environment.

- We learned that in co-production practices (principle 1) the collective dimension can be further developed and strengthened so as to offer teachers even more opportunities to learn from each other by fostering co-creation across different schools. Unfortunately, due to the Covid-crisis (see above), we did not succeed in gathering several schools for the pilot trajectory in collaboration with PNC. However, we observed the value of sharing experiences and good practices from other schools through that kind of interventions from MOS coaches (see above). It should be further explored in the future how collective LORET trajectories for several schools can optimise opportunities for teachers to learn from each other. In addition, digital possibilities for that in relation to the SEAS library should be explored.

- We experimented with how we can make (emerging) insights from educational research to be helpful for practitioners (principle 1). For example, research done on the risks and opportunities involved in addressing real-world sustainability problems in education resulted in the concept of 'didactical carving' (Van Poeck and Östman 2020) which has been transformed into a practical didactical tool to be used in the LORET workshops.

- We identified several relevant teaching challenges (principle 2) specific for a context of open schooling, for example selecting and delineating a 'suitable' problem, selecting teaching content (in the curriculum as well as in the local environment and community), organising

the teaching in such a way that it takes the students along in an authentic problem-solving process that offers them unique pedagogical opportunities.

- We identified some challenges involved in making sure that the outcomes of LDWs are useful products – lesson plans and teaching materials – for teachers to take home after the workshop (principle 3). It requires time for teachers to work individually to prepare or to process the workshop meetings which can be stimulated and facilitated by well-chosen preparatory assignments. Pioneering work has been done in the pilot schools: the teachers engaged in manners of teaching that can be seen as a 'niche practice' in the Flemish educational system (see further below). Therefore, and especially if we want to mainstream LORET in more and more schools, it is important to provide teachers with inspiration, for instance by creating exemplary LORET plans[18] or by offering infrastructure (the SEAS library) for sharing outcomes.

- Our experiences in the LORET workshops and throughout the collaboration in the partnership shows that, in order to facilitate, 'fuel' and nourish the process of continuous refinement (principle 4), it is vital to combine digital tools and infrastructure (SEAS library) with the possibility for dialogue among teachers. Well-chosen activities are important to encourage teachers to share, but also to refine and contextualise each other's lesson plans and teaching materials. In order to keep the much-needed professional community alive, intermediary organisations such as MOS, environmental education centres, NGOs can play a vital role.

Lesson Design Workshops are very time-consuming and resource-intensive. In order to legitimise that level of investment, the benefits and impact must move beyond a single school, (group of) teacher(s) and series of lessons. We will further elaborate the importance of and possibilities for sharing and upscaling impact in the next section.

SEAS library

Our analysis of the Belgian SEAS open schooling partnership revealed several strengths and opportunities for 'upscaling and sustaining impact', but also some weaknesses and threats involved in this challenge (see above). These insights will be useful for EduQuality in view of the further development of a Belgian SEAS library.

Based on this analysis, we identified key principles that have also been validated by EduQuality in other contexts and that will be helpful for establishing libraries in other SEAS countries and beyond:

Key principles for SEAS library
Prioritising the quality of lesson plans and teaching materials over the quantity of uploaded contributions

[18] A training for trainers on LORET for MOS coaches is planned in Spring 2022 which will be organised as a hands-on training where the participants will create LORET plans. We believe this will result in valuable examples that can be uploaded and shared.

Using (LORET) lesson design workshops and other 'maker spaces' where teachers, content experts and didactic experts co-create lesson plans and teaching materials as a quality care tool prior to uploading
Organising the SEAS library as a vehicle for commons-oriented peer-to-peer production
Focusing the efforts on attracting, supporting and empowering a specific segment (niche) of possible users: those who are willing and able to create and share high-quality lesson plans and teaching materials (active 'uploaders')
Creating a common marketing and communication strategy to attract 'downloaders' and to encourage them to engage in quality care through giving feedback and uploading variants of downloaded lesson plans and teaching materials
Finding ways to continue the work done by the temporal SEAS partnership after the termination of the project
Finding (additional) partners willing and able to share/finance the costs for continued work
Developing a fair system for acknowledging and compensating contributions

These general principles will now have to be further developed into **well-considered strategies for how to sustain and accelerate the impact of SEAS, both in Belgium and internationally**. The latter is a task of EduQuality within the consortium for which, we believe, the Belgian pilot case has provided useful insights. The challenge is to build on and expand the existing open schooling partnerships and develop into a long-term, commons-oriented collaboration.

The explorative work done in the Belgian network in collaboration with EduQuality revealed **great potential for the SEAS libraries in combination with (LORET) Lesson Design Workshops and other 'maker spaces' to foster peer-to-peer co-creation of high-quality lesson plans and teaching materials for open schooling and sustainability education**. From the perspective of the Belgian open schooling network, we can conclude that the work done in the SEAS project allowed to create a solid foundation for that. In a meeting with the P2P Foundation's founder Michel Bauwens, he described a general principle regarding the division of commitment within commons-oriented P2P initiatives: the '1-9-90 rule'. Usually, he explained, about 1% of the people involved can be considered the core group that drives the P2P community and invests a lot of time and energy into it. 9% can be considered active contributors (i.c. for example active uploaders of materials on the library, reviewers, active workshop participants) while the engagement of the remaining 90% is limited to the rather passive usage of the commons (i.c. these could be the 'downloaders'). Very encouraging to hear, though, was that if one manages to make the 1% grow in absolute terms, the 9% and 90% usually grow to a similar extent. Hence the challenge to expand the 'core group' to drive and govern a partnership for peer-to-peer co-creation of high-quality lesson plans and teaching materials beyond the duration of the SEAS project.

Within the Belgian context but also in view of EduQuality's further work on upscaling and sustaining impact, **the following issues require further clarification and exploration**:

- How to organise and govern partnerships based on contributions and reciprocity?
- How to deal with intellectual property rights?
- How to finance the costs and compensate contributions?
- How to regulate the governance and use of the commons (e.g. fair licensing, multi-agent incentive system)?

- What role can governments, businesses and civil society play in such partnerships?

Conceptual model(s)

In this section, we synthesise our findings with the help of conceptual models. We describe and further elaborate our work on piloting and further developing the LORET tool with the help of the 5Es model. Our findings regarding how LORET-based open schooling can disturb and transform teching habits and customs as well as how we can upscale and sustain the impact of the open schooling are discussed with the help of the multi-level perspective on sustainability transitions.

5Es model

In open schooling partnerships, the relation between students, teachers and partners outside the school can take shape in varied ways. LORET aims to shape these partnerships and relationships in accordance with two crucial principles. First, LORET aims to connect engagement with societal problems with the realisation of pedagogical aims and objectives – the core task and 'raison d'être' of schools. Second, LORET supports teachers to approach students as subjects of change – part of the solution – instead of as objects of change – part of the problem. This reflects, on the one hand, a normative position about the role of education in relation to societal problems, a topic of lively debate in educational scholarship (see below – dilemmas: Learning *for* versus learning *from* sustainable development). As it is not the responsibility of students, teachers and schools to solve societal problems, LORET supports teachers in their *didactical* and *pedagogical* work and deliberately aims to avoid the instrumentalization of education (Van Poeck and Östman 2020, Säfström and Östman 2020). On the other hand, the guiding principles behind LORET are built on the assumption that working with real-world problems offers unique pedagogical opportunities.

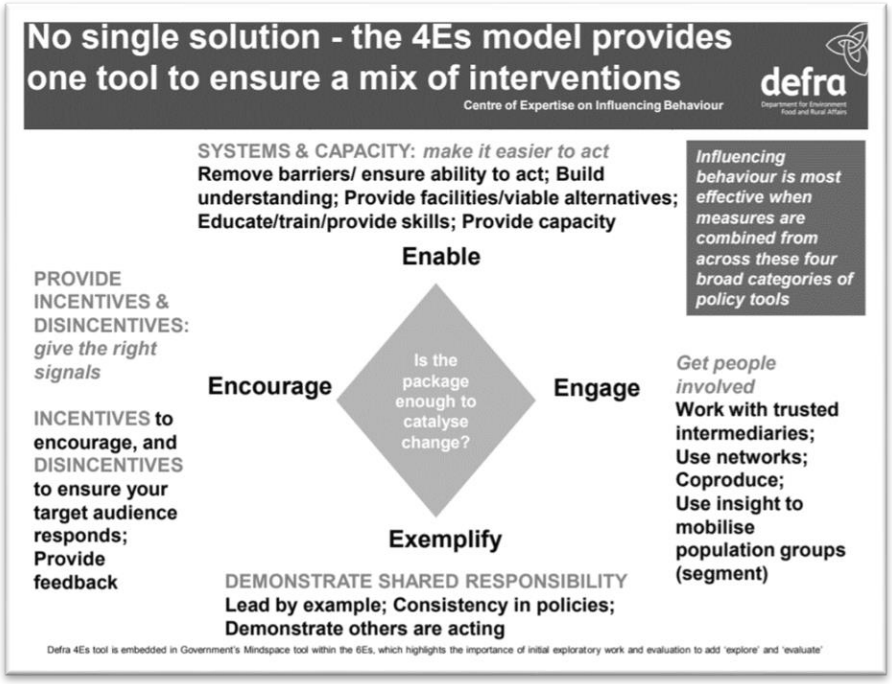
> *'Not only does it offer students the chance to acquire specific knowledge, insight and skills, it also fosters creativity, experiences of being able to make a difference and space for engagement and commitment. Furthermore, the students can experience how different people may each have their own idea of how they can / want to solve this problem. Engaging students in the quest for solutions hence enables educative moments that would not emerge during theoretical lessons or mere reflections in classroom discussion where no 'real' challenge is at stake. When dealing with real-world problems, what is said and done is not non-committal. One has to find a solution together. Not everyone thinks the same, there may be resistance. And finally, the work of the students results in something that is practically useful which in itself is more satisfying than if one sticks with the theory.' (https://loret.se/background/)*

An earlier described model that shares these principles, is the '5Es model' as described by Van Poeck (2010) in response to the way in which DEFRA's 4Es model (see below) has been used in educational contexts. In the remainder of this section, we explain this model, discuss how LORET can be employed to support teachers in the didactical work needed to implement it and how LORET and the 5Es can be used as complementary didactical guidance for designing and performing open schooling practices.

DEFRA's 4Es model

DEFRA (2008), the UK Department for Environment, Food and Rural Affairs, developed a framework for developing effective behavioural change strategies based on a mix of tools, the 4Es: Enable, Encourage, Exemplify and Engage. The 4Es model assumes that the gap between environmentally friendly attitudes of many people and the lack of sustainable behavioural patterns is caused by a variety of barriers. These obstacles are situated at the level of structures (e.g. institutions and power relations), culture (e.g. worldviews and values) and practices (e.g. routines or rules). Deploying the 4Es should make it possible that cultural-psychological changes and structural changes go hand in hand – a prerequisite for the transition to a sustainable society.

- 'Enable' is about making sustainable lifestyles easier by providing people with the support they need to make responsible choices. These must be available, simple and self-evident, while unsustainable alternatives should be excluded from the range. Barriers should be removed and the ability to act ensured by, for example, providing facilities, viable alternatives, skills, etc.
- 'Encourage' is about giving the right signals. It means that sustainable behaviour is not only made possible but also encouraged through providing incentives and disincentives. This can be done through pricing, by stimulating sustainable choices (for example via subsidies) and discouraging unsustainable choices (for example fiscally). External costs must be internalised.
- 'Exemplify' is about demonstrating shared responsibility. It involves leading by example, consistency in policies, and demonstrating that others are acting. It explicitly refers to the exemplary role of governments.
- 'Engage' is about getting people involved. It involves raising awareness, involving people early on so that they understand what they need to do and develop a sense of personal responsibility, using networks and working with trusted partners and intermediaries to develop 'social norms', and moving entire communities.



(source: https://www.sustainabilityexchange.ac.uk/files/defra_sustainable_lifestyles_framework.pdf)

The 4Es model thus also sees a role for learning processes and education. However, a risk is that everything related to learning is situated exclusively under the 'Engage' pillar (e.g. Jones and De Meyere 2009) in order to engage as many people as possible in realising the desired change together. Education and awareness-raising should, in this perspective, provide the necessary support for the desired transition. However, reducing education to the 'Engage' pillar implies that determining the goals of the transition as well as choosing the means to realise these goals falls outside the scope of the teaching and learning process. In other words: it is only *after* deciding what needs to be done, that students can get involved. Another risk is that education is, as in the figure above, reduced to 'training' in view of acquiring the skills needed to be able to act in the desired way, as part of 'Enabling' the desired transition.

Such approaches provide students with the kind of solutions we currently go to for the problems that arise today. But what is the shelf life of ready-made solutions in our complex and rapidly changing world? And what if a 'solution' later turns out to be a (new) problem? Or when we are confronted with conflicting arguments for and against proposed solutions? How can students learn to deal with that if the crucial decisions are made in advance, by others? How can we move beyond treating students as consumers who must learn to make sustainable choices ('objects' that need to be changed) and treat them as citizens who are able to critically question and try to transform structures, cultures and practices ('subjects' that contribute to realising change)?

A 5th E

These questions inspired the introduction of an adapted framework: a 5Es model (Van Poeck 2010) in which education is approached differently. After all, as we will further elaborate below (see dilemmas), there are crucial differences between 'education' and 'influencing behaviour'. Teaching and learning are in the 5Es model not limited to the 'Engage' pillar – in order to create support for changes desired and proposed by others – nor to a matter of training specific skills in order to 'Enable', again, what others have decided. Only if **'Education'** – the 5th E – involves the students in exploring and experimenting with all of DEFRA's 4Es, they can learn to find solutions for complex and unpredictable problems themselves, now and in the future, and take on their role as citizens.

Education as a 5th E aims to equip people with the capabilities and the commitment to actively contribute to sustainability transitions. Not with the intention of solving sustainability problems once and for all – besides that this is not the responsibility of schools it would reflect an overestimation of the potential of education – but to offer students the opportunity to develop themselves as citizens who are willing and able to participate actively in a democratic, socially just and environmentally sustainable society. The purpose of education then moves beyond equipping students with the 'right' knowledge, skills and attitudes to function efficiently and obediently in a society as it is conceived *for* them. Instead, it offers them opportunities to become involved in envisioning a sustainable society and ways of realising it. They think about what behaviour should be possible ('Enable') and how this can be stimulated ('Encourage'). They critically examine the government's exemplary role and denounce inconsistent policies ('Exemplify'). And they themselves look for ways to involve as many people as possible with diverse backgrounds in this process ('Engage').

LORET and 5Es

Obviously, LORET and the 5Es model share a **similar philosophy** in that they aim to offer students unique educational opportunities by taking them along in an authentic quest for tackling real-world sustainability problems. In other words: they strive for learning *from* a quest for sustainable development rather than learning *for* a sustainable development predefined by others (see below – dilemmas). The 5Es model, however, can be seen as a general principle/idea and does not offer any **didactical support for teachers with respect to how to design and implement that sort of education**. LORET can fill that gap. As explained above, it helps teachers to select a suitable focus (i.e. a locally relevant sustainability problem that is manageable for the students while still being an authentic challenge) as well as to select teaching content and design lessons that take the students along through all phases of a sustainability problem-solving process (i.e. exploring the problem, coming up with possible solutions, implementing solution proposals, and evaluating the problem-solving).

Through LORET-based open schooling, teaching can – in line with the 5Es – make students attentive to and let them experiment with the 'Enable', 'Encourage', 'Engage', and 'Exemplify' dimension of creating a more sustainable society. While exploring a locally relevant problem, they can address questions and gain insight into which sustainable choices and alternatives are (locally) available and which are not, why this is the case, whether or not policymakers and/or the school management lead by example, which choices are encouraged or discouraged, etc. In the phase of coming up with possible solutions, the students can look for answers on questions such as which sustainable alternatives should be enabled, which incentives could be employed for encouraging sustainable choices, how to remove 'wrong signals', and which partners in the local community could be helpful for engaging people. While implementing solution proposals, they can engage with trying to make sustainable choices possible, seeking support from the management or municipality, making sustainable alternatives more attractive, trying to demonstrate action, involving more people, etc.

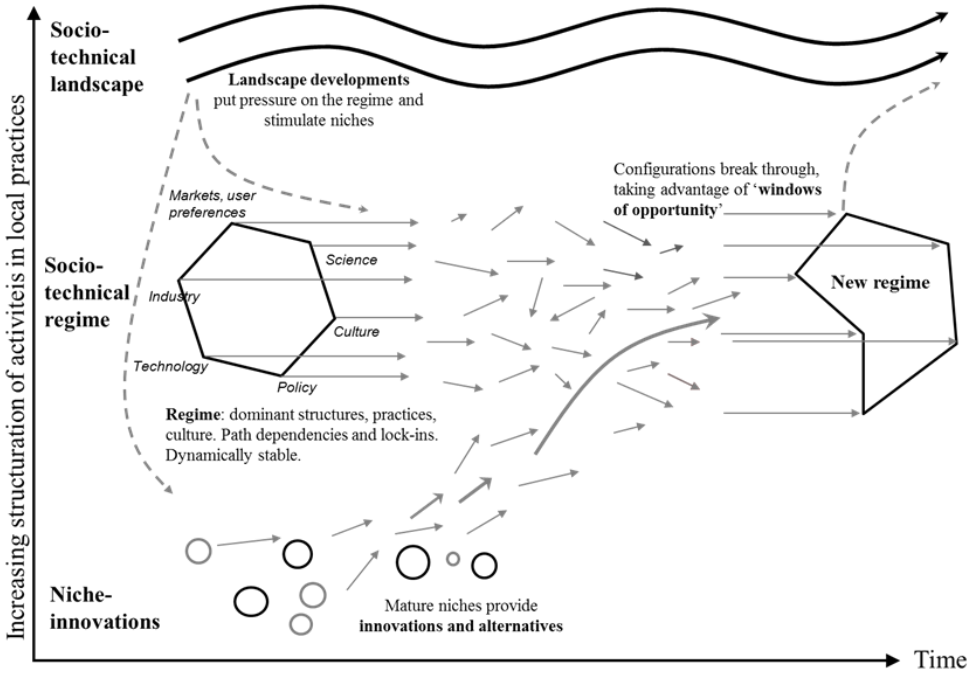
While LORET adds didactic guidance to the 5Es model, the latter can in return **help teachers to make the content of their lessons and the activities offered to the students more concrete and to do so with a broad view on obstacles and opportunities for making our society or local community more sustainable**. This is important, especially since our analyses reveal that teachers can use more guidance in how to teach about (generating) possible solutions for sustainability challenges (see above), about alternatives for the future and about strategies for realising change (see below – action-oriented knowledge).

A multi-level perspective on sustainability transitions

'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).

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 above elaborated findings of our local assessment and for raising some promising prospects for future research.

As our analysis of how LORET disturbs teaching habits and customs as well as the 'external analysis' of threats and opportunities related to the target audience of the library of lesson plans and teaching materials shows (see above), 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**. 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).

This explorative multi-level perspective on how open schooling 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 *un*lock 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.

Identifying Dilemmas: Learning *from* instead of *for* sustainable development

In educational research – incl. Environmental and Sustainability Education (ESE) research – there is an ongoing scholarly debate about the role of education in relation to societal transformation. This debate is characterised by a tension between two perspectives. On the one hand, we have a radical pedagogical perspective, emphasising the risks involved in reducing education to an instrument for predetermined societal change (e.g. Biesta 2006, Masschelein and Simons 2013, Säfström 2011, Todd 2011). On the other hand, we find a radical emphasis on the urgent need for a transition towards a more sustainable world (Block et al. 2018). Both perspectives can be seen to be based on legitimate concerns (Van Poeck and Östman 2020). First, a concern about the 'instrumentalisation' of education that risk rendering students, schools and universities into objects of desires and goals determined by others (Säfström and Östman 2020 – see also above: 5Es). Second, a concern for the urgent need of widespread engagement and mobilisation for coping with the severe consequences of socio-ecological problems.

LORET-based open schooling is designed as an approach that strives to take these two legitimate concerns seriously – an approach where students can engage with urgent and far-reaching sustainability challenges without being reduced to instruments for externally determined demands. Our analyses presented above shed light on obstacles and opportunities to do so and thereby illuminate what it means and implies to design and implement what Van Poeck and Vandenabeele (2012) have labelled 'learning *from* sustainable development' – as opposed to the more dominant idea and practice of 'learning for sustainable development'. Learning *from* sustainable development shifts the focus from training for preassigned competences that students must acquire (learning *for*) towards what students can learn, again and again, in response to what they encounter when facing real-world sustainability issues in educational practices. Education, then, is not a matter of schooling through which students and schools are instrumentalised but an educational practice that takes students along in a continuous quest for how to cope with puzzling matters of concern. Instead of offering students predetermined answers, it exposes them to difficult questions and to the plurality

of voices on and possible controversies surrounding sustainability issues, inviting them to voice their own stories, opinions and values and to contribute to the learning process from their own perspective. And, since the students are dealing with real-world challenges that are never indifferent, learning *from* sustainable development can avoid the pitfall of anything-goes relativism.

Reporting area 2, Belgium: Challenges and opportunities with regards to transformational engagement, scientific literacies, and motivation

Methods

Data sources and Participants

In the Belgian local network, we focus the assessment of challenges and opportunities with regards to transformational engagement, scientific literacies, and motivation on how LORET-based open schooling (see above) can foster students' willingness[19] and ability to act upon sustainability problems.

Besides the quantitative assessment done through SEAS' Global Assessment Instrument (D5.1), we conducted a qualitative assessment of the outcomes of LORET workshops as well as of classroom/in-school/out-of-school activities. We collect data from the following sources:

- Video- and audio-recordings of classroom activities
- Video- and audio-recordings of out-of-school activities
- Video- and audio-recordings of meetings + transcripts
- Video- and audio-recordings of LORET workshops + transcripts
- Field notes of meetings and LORET workshops
- Video- and audio-recordings of interviews with teachers + transcripts
- Documents (for content analysis): policy documents (curriculum goals), LORET plans, LORET workshop assignments, lesson plans, teaching materials, student work, emails, etc.
- Research literature

In addition to the data-set listed in Chapter 1: 'Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface' (see above), we collected the following data:

DATE	WHAT	DURATION
2/3/2020	A classroom activity: Kick-off cCHALLENGE in 3rd grade of secondary school (pilot school 2): 2 classes with in total 41 students, 2 teachers	2h26
6/3/2020	A lesson of the subject 'Fundaments of democracy' in 3rd grade of secondary school (pilot school 2): 16 students of the 3rd grade of secondary, 1 teacher	1h49

[19] Considering our concerns about 'learning *for* sustainabile development' (see above), this willingness to act should not be understood as a willingness to merely obediently follow behaviour guidelines defined by others. Also in the 'Dilemmas' section of this and the following chapter we will further elaborate on this in relation to debates in educational/ESE research (see below).

16/9/2020	An out-of-school activity: a visit to the farm in 3rd and 4th grade of primary school (pilot school 1): 7 students, 1 farmer, 1 supervisor (parent)	2h47
16/10/2020	An out-of-school activity: a visit to the farm in kindergarten (pilot school 1): 8 toddlers, 1 teacher, 1 supervisor (parent)	3h40
16/10/2020	Interview with a teacher of pilot school 1	30'
March '20	Platform activity on CHALLENGE 'Food for thought'	N/A
22/3/2021	A lesson physics + geography: 12 students, 2 teachers	48'
22/3/2021	Excursion to collect water samples (during lunch time): 6 students, 1 teacher	11'
22/3/2021	A chemistry lesson: 12 students, 2 teachers	48'

Analytical procedure and approach

Our overall research question is: How to foster transformational engagement, scientific literacies, and motivation to act upon sustainability challenges through LORET-based open schooling?

We address this overall question through the following sub-questions:

1. What sort of knowledge[20] is needed to foster transformational engagement, scientific literacies, and motivation to act upon sustainability challenges?
2. What are enabling conditions for open schooling to foster the acquisition of that sort of knowledge?
3. What are obstacles for fostering the acquisition of that sort of knowledge?
4. What is the influence of the institutional context?
5. What is the influence of teachers' practices?
6. What is the influence of LORET workshops and assignments?

Theoretical framework

For our qualitative analysis we use existing theoretical frameworks that have been applied earlier in research literature. First, a model on action-oriented knowledge (Jensen 2002, 2004) serves to provide a spectrum of different dimension of knowledge. In a time where our planet and its inhabitants are exposed to accelerating sustainability crises that require resolute and urgent action, ESE practice and research is faced with questions such as: how to avoid 'eco-paralysis' (Albrecht 2011) that can arise from feelings of worry, anxiety, and 'ecological grief' (Ojala et al. 2021)? How to overcome the gap between *knowing* about sustainability problems and *acting* in the pursuit of tackling them (Kollmuss and Agyeman 2002, Kenis and Mathijs 2011)? Observing that knowledge does not *per se* lead to action, Jensen (2002, 2004) problematises how knowledge is typically taught in formal education, i.e. in a way that is not sufficiently action-oriented. He distinguishes four types of knowledge through which sustainability problems can be approached and analysed:

(1) knowledge about the existence and consequences of the problem ('WHAT is the problem?')
(2) knowledge about its root causes ('WHY do we have this problem?')

[20] We realise that transformational engagement, scientific literacies, and motivation involve more than only knowledge. However, because of the analytical framework used in this assessment (see below), we mainly focused on (action-oriented) knowledge in our investigation. Below we will problematise this and suggest an adaptation of the framework.

(3) knowledge about alternatives and visions ('WHERE do we want to go?')
(4) knowledge about strategies for change ('HOW do we change things?')

All too often, Jensen argues, ESE offers students a limited 'landscape of knowledge' that is not necessarily conducive to action as it reduces the focus to solely the type of knowledge about the existence and consequences of the problem. Although this knowledge, often coming from the natural sciences, is important to raise concern, attention, and a certain willingness to act, it does not provide students with an explanation for why we have these problems and might even, if taught in isolation, have an adverse effect by contributing to 'action paralysis' (Jensen 2002, p. 330). For education to be action-oriented, the author argues, it should strive to explore and develop all four dimensions of knowledge about sustainability problems. The second, 'causal' dimension of root causes of sustainability problems includes, besides knowledge about physical factors also knowledge about social and economic factors that influence our behaviour as well as societal structures, cultures, and practices. The dimension of knowledge about alternatives and visions is about developing one's own visions and seeing possibilities for forming and developing one's dreams and ideas for the future. It includes knowledge about ways of thinking and doing in other times, places, and cultures since knowledge about alternative possibilities can be a powerful source of inspiration for developing one's own visions. The strategies for change dimension, finally, encompasses knowledge about how to control one's own life as well as about how to contribute to a change of living conditions in society at large. It involves psychological, political, and sociological knowledge about both direct and indirect possibilities for action, about how to encourage cooperation, how to analyse and deal with power relations, etc.

Second, we employ transactional teaching theory (Östman et al. 2019, Van Poeck and Östman 2021) to gain insight into how the learning of action-oriented knowledge is enabled, facilitated and steered by the practices of teachers. The focus is on concrete actions of teachers, i.e. on what they *do* both in the preparation of education activities and in the implementation. Inspired by so-called 'dramaturgical analysis' (Feldman 1995, Hajer 2005, Nahuis 2009), transactional teaching theory uses metaphors derived from dramaturgy to understand and investigate how what people do is determined by the setting in which they do it – and vice versa. Students' learning is thus seen as being influenced by the setting that teachers create for it – and how students acting within and upon that simultaneously and reciprocally influences the setting. The practice of teaching includes the preparatory work for planning and designing lessons as well as the actual implementation of the prepared lessons. With a dramaturgical lens, we approach this teaching practice in terms of 'scripting', 'staging' and 'performance' (Van Poeck and Östman 2021).

- The *scripting* involves formulating purposes for the learning process and to determine the roles of teacher(s) and students, including expectations regarding how all participants are supposed to behave in this setting. Scripting thus concerns choices and actions with regard to describing educational objectives for a course or lesson, determining which teacher(s) teach(es) it, which students follow it, how the students are expected to behave, etc.

- *Staging* involves creating education activities through designing a learning environment, a 'scene', in which certain objects / phenomena are brought to students' attention as well as designing tasks through which the students actively engage with the objects of attention. It is about choosing teaching matter and teaching materials, arranging and equipping the classroom, giving instructions, determining whether students will work in groups and how to organise them, planning and monitoring the time that can be spent on tasks, etc.
- In the *performance*, the prepared lessons are put into practice. The teacher makes all kinds of interventions – so-called 'teacher moves' (Östman et al. 2019b – see also above) – that help guide the students' learning. Teachers' interventions can be verbal (saying something) or non-verbal (e.g. showing something, nodding, pointing at something, moving in space). They can add something to the students' attentiveness, steer the learning process in a certain direction or deepen it.

Through acts of scripting, staging and performance, teachers have an important influence on what students learn. This always involves governing processes of inclusion and exclusion in terms of which phenomena to focus on and which ones to neglect as well as what to do with the objects of attention. They direct the students' attention to certain things (and thus not to – or even away from – other things) and give direction to how the students get to work with the object brought to their attention. This affects the inquiry that drives learning (see above).

Methodology

We use thematic analysis to analyse documents (policy documents on curriculum goals, LORET workshop assignments, LORET plans, lesson plans, teaching materials, student work) as well as transcripts and field notes of observed LORET workshops and lessons. Sensitising concepts derived from the above elaborated theoretical frameworks constitute the initial coding scheme: the dimensions of action-oriented knowledge and the aspects of 'scripting' ('roles', 'purposes'), 'staging' ('staging a scene', 'staging tasks') and 'performance' ('adding', 'directing', 'deepening'). Unfortunately, due to Covid-restrictions (see below), we have not been able to gather as many data from observed lessons as we initially planned to do.

The first step of our analysis is to specify how each dimension of action-oriented knowledge can be operationalised through LORET-based open schooling (question 1). Therefore, we scrutinise the data looking for empirical evidence of whether and how knowledge about the existence and consequences of the problem, about the root causes, about alternatives and visions, and about strategies for change is addressed.

Then, in order to identify enabling conditions and obstacles for the acquisition of action-oriented knowledge (question 2 and 3), we conduct the following analyses:

- Scrutinising policy documents in order to **screen curriculum objectives** with regard to whether/how they address the four dimensions of action-oriented knowledge[21] (question 4).
- Scrutinising the data looking for empirical evidence of how **teachers' preparatory work of designing LORET lessons** (i.e. their scripting and staging) affect students' opportunities to learn action-oriented knowledge (question 5).
- Scrutinising the data looking for empirical evidence of the **influence of LORET workshops and assignments** on how teachers can foster action-oriented knowledge (question 6).

Findings

Action-oriented knowledge in LORET-based open schooling

Our analysis of workshops and assignments, LORET/lesson plans, and teaching materials reveals that **all dimensions of action-oriented knowledge can been addressed in LORET-based open schooling**. Below, we illustrate this with examples for each of the four dimensions coming from the LORET plan of pilot school 3. They focused on the topic of water and challenged their students to find solutions for better water management on the school campus. They used the concept of the 'black box' suggested by a MOS coach (see above) for planning lessons in the subjects of geography, physics, chemistry, ICT, and STEAM.

Knowledge about the existence and consequences of the problem

In their LORET plan, the teachers include several lesson goals related to fostering knowledge about the existence and consequences of sustainability problems related to water. For example:

- *'Students know the vocabulary related to water scarcity and water footprint'*
- *'Students can define regions with water scarcity on the world map'*
- *'Students have an idea of the (physical) magnitude of the water problem'*

In the description of the content of the planned lessons, this dimension of knowledge is also clearly present. Content addressed is for example:

- *'Water footprint'*
- *'Water scarcity'*
- *'Absolute water scarcity'*
- *'Water stress'*

Planned lesson activities and teaching methods related to knowledge about the existence and consequences of the water problem are, for instance: *'Students define regions with water scarcity based on maps'*.

[21] Due to the challenges involved in an unambiguous understanding of the Flemish curriculum goals (see above), we opted for researcher triangulation (Patton 2002) and involved two different researchers (i.c. Nordin Bigaré and Katrien Van Poeck) in screening the targets and discussing the results.

Knowledge about its root causes

Knowledge about the causes of the water problem is also addressed in the lesson goals:

- *'Students look for causes of water scarcity and water stress in Flanders'*
- *'Students have an idea of the water consumption in Flanders'*
- *'Students know their own water consumption and can quantitatively link that water consumption with different needs.*

Lesson content mentioned in this respect is *'water consumption in Flanders'*.

Several lesson activities and teaching methods are related to knowledge about the causes of the water problem. For example:

- *'Students study statistics on water consumption in Flemish households'*
- *'Students calculate their own water footprint'*
- *'Students monitor the water consumption in their own home for a week (check meter)'*

An example of an assignment for the students:

> *'Check the water meter of your house (or your school) and write down the result. Do this every day for a whole week, every time at the same hour (i.e. morning or evening). More times a day is also allowed. We are going to make a nice graph of this! Always note the time.'*

The teachers connect these goals, the content, and activities to the curriculum objective *'Recognising the horizontal and vertical relationships that explain water scarcity in the studied region'*.

Knowledge about alternatives and visions

In the way teachers include knowledge about alternatives and visions in their LORET plan, we can recognise the influence of the 'black box' concept suggested by the MOS coach: ensuring that there is as little influx of water as possible, making sure that you keep that water in the school as long as possible (buffer capacity), and ensuring that the outflow of the water is as clean as possible.

We found the following lesson goals:

- '*Students calculate how much rain water falls at the school campus and what happens to that water afterwards'*
- *'Students can calculate the cost for storage and use of the rain water that falls on the school campus'*

In order to foster knowledge about alternatives and visions, the following lesson activities and teaching methods are listed:

- *'Students make an initial estimate of how much water is used at school'*
- *'Students find out for themselves what could be done with the rain water falling on the school campus'*
- *'Students do some quick exercises to investigate whether water storage is realistic'*
- *'Students find out what is included in the cost of water storage: distribution, filtering, storage, inflation…'*
- *'Students look up and calculate a lot: potential energy + efficiency of pump, calculate pressure'*

- *'Making a water filter'*

An example of an assignment for the students:

> *'Calculate how much water falls*
> *- on the roof of the school*
> *- on the playground*
> *Mr [name teacher] explained how you do that. His explanation can be found in the powerpoint of the first lesson [link added].'*
>
> *'During this holiday week you have to make your own water filter. After the holidays, you take it to school to filter waste water. The better the water quality of the filtered water, the better grades!*
> *We will check the water for some parameters. We had also thought of letting you drink the water as a test, but the safety and health committee at school does not allow that. So maybe we'll test it for water fleas.*
> *The design is completely free. You can get a lot of inspiration on the internet. Search for "DIY water purifier" or "make your own water filter". You are not supposed to buy material!*
> *Good luck,*
> *the science teachers'*

The teachers connect these goals, content, and activities to the following curriculum objectives:

- *'Explaining how the problem of water scarcity can be reduced through technological evolution'*
- *'Taking sustainable development in time and space into account in their actions'*
- *'In clarifying and seeking solutions to sustainability issues, apply scientific principles related to resource consumption, energy use and the environment'*
- *'Displaying values correctly in calculations, taking into account significant figures'*
- *'Applying the efficiency of energy conversions qualitatively and quantitatively'*

Knowledge about strategies for change

When it comes to knowledge about strategies for change, students are offered lessons through which they will learn possible *indirect* actions that can be taken to improve the water management on the school campus: trying to convince the school management to implement their suggested solutions.

The lesson goal related to that in the LORET plan is:

> *'Students write a report for the school management. The students are asked to write a 'Concrete, numerically substantiated report for the school management to defend the necessity of water storage and use'.*[22]

[22] Important to notice, here, is that this LORET plan was created before we split-up the workshop session on creating a LORET plan in two parts (see above). This is an example of how it turns out to be difficult for teachers to plan lessons on implementing solutions before they know which solution proposals the students will generate. What we see here, is that the teachers already suggested/decided upon a solution which is, as argued above, at odds with LORET's ambition to design lessons in which students can do that and learn from it.

The assignment for the students looks as follows:

> *'Prepare a first report on the water project. Make the report readable, put a suitable photo or graph where possible. Pay attention to accurate scientific spelling. Values have a correct unit! If you look up something, you must cite the source.*
>
> *The report contains the following topics:*
> *- Water consumption at school: How much water do we use at school?; What is the roof area of the school (+picture)?; How much rain water falls on the roof of the school per year? How much on the playground?*
> *- Water consumption at home: Give a (bar) graph of consumption of seven days; How much is that per person per year?; How much does an average family / person use per year? (search)*
> *[…]*
> *- Water quality of different samples: Where did the samples come from?; Provide the table with all tested samples + test results*
> *- Water filter: Describe your water filter (how, what is good, what could be better); Flow?; Test results?'*

This lesson has not yet taken place. In a follow-up workshop with the teachers, we – as LORET workshop facilitators – will encourage them to further support the students in this work by including knowledge about how to write in a convincing way, how to develop a high-quality argumentation, and what are (other) possible strategies to try to convince the school management to implement changes.

Enabling conditions and obstacles for action-oriented knowledge

For our analysis of enabling conditions and obstacles for action-oriented knowledge, we investigated the influence of the institutional context (curriculum), the influence of teachers' practices, and the influence of the LORET methodology. In the next section, we describe how teaching and learning action-oriented knowledge is enabled or constrained by the Flemish curriculum. In the subsequent section, we address how LORET tools, assignments and workshop exercises affect teaching practices (scripting – staging – performance) in view of action-oriented knowledge.

Action-oriented knowledge in the curriculum

In order to identify **enabling conditions and obstacles for action-oriented knowledge in the curriculum of Flemish education**, we screened the attainment targets as to whether and, if so, how the four different dimensions of action-oriented knowledge are addressed in it. As also explained above (see 'Working with LORET in the context of the Flemish curriculum') it is impossible to systematically screen all the different curriculum plans. Therefore, we focused on the attainment targets which, as indicated, are 'soberly' and often vaguely, abstractly and/or formalistically formulated. Again, this implies that it was often not possible to unambiguously connect 1 target to 1 particular dimension of action-oriented knowledge since so much depends on how an umbrella organisation or a school operationalises the attainment target into an objective in their (various) curriculum plans. As exemplified above, curriculum target such as *'displaying values correctly in calculations, taking into account significant figures'* can be addressed through teaching action-

oriented knowledge on visions and alternatives, but whether or not this is the case entirely depends on how the teacher operationalises them in their lessons.

Below, we present a non-exhaustive list of examples that illustrate how the different dimensions of action-oriented knowledge can be identified in the attainment targets of both primary and secondary education in Flanders. This reveals a potentiality which can be considered as an enabling condition. Yet, the soberly formulated curriculum goals are at the same time an obstacle or a possible pitfall since not all teachers and schools will relate them to all dimensions of the wide landscape of action-oriented knowledge.

Knowledge about the existence and consequences of the problem

In primary education:

- *Students are able to illustrate that labour migration and the issue of refugees have played a role in the development of our multicultural society.*
- *Students can illustrate that wealth is unevenly distributed both across countries in the world and in Belgium.*
- *Students understand the main consequences of increasing automobile use and be able to compare the advantages and disadvantages of possible alternatives.*
- …

In secondary education:

- *Students explain the complexity and interconnectedness of sustainability issues.*
- *Students explain the impact of global challenges of sustainable development on the local level.*
- *Students discern both bigotry and discrimination in society.*
- *Students explain the mechanisms of prejudice, stereotyping, abuse of power, and peer pressure.*
- *Students illustrate social justice and injustice using specific examples.*
- *Students reflect on spatial impacts of demographic and economic processes at different spatial scales. (e.g. environmental impacts: soil erosion, land degradation and others such as acidification, eutrophication, fragmentation, water scarcity, deforestation)*
- *Students analyse characteristics of contemporary societies using sociological concepts. (e.g. individualisation, socialisation, social control, modernisation, transformation, stratification, social mobility, division of labour, secularization, emancipation, rationalisation, power struggle)*
- …

Knowledge about its root causes

In primary education:

- *Students can illustrate that humans influence the presence of organisms.*
- *Students realise that their behaviour is influenced by advertising and the media.*
- *Students can illustrate that different forms of employment are differently accessed and valued by men and women.*
- *Students can illustrate how the price of a product is determined with an example of their own choosing.*
- *Students can illustrate with specific examples from their environment that environmental problems often involve competing interests.*
- …

In secondary education:

- *Students explain the complexity and interconnectedness of sustainability issues.*
- *Students illustrate that landscapes evolve under the influence of physical and socio-geographic changes.*
- *Students explain that organisms with certain characteristics, in a well-defined environment, are more likely than other organisms to survive and reproduce.*
- *Students illustrate how systems thinking can be applied to sustainability issues. (e.g. cause-and-effect relationships, distinctions of whole - part within systems, different perspectives, uncertainty)*
- *Students will examine economic processes at different spatial scales. (e.g. mining of raw materials, modes of production: traditional versus modern, sustainable versus unsustainable, extensive versus intensive)*
- *Students reflect on spatial impacts of demographic and economic processes at different spatial scales. (e.g. urban-rural shifts: rural urbanisation, rural depopulation, urban growth, evolution in mobility, urban agriculture; patterns in cities such as social segregation, multiculturalism, changes in function; effects of urbanisation on the urban environment such as air pollution, congestion, hardening, formation of heat island)*
- *…*

Knowledge about alternatives and visions

In primary education:

- *Students can illustrate that different social and cultural groups possess different values and norms.*
- *Students can compare aspects of daily life in a country of another cultural area with their own.*
- *Students understand the main consequences of increasing automobile use and are able to compare the advantages and disadvantages of possible alternatives.*
- *Students can illustrate by example that a current condition, recognisable to children, and influenced by history was different in the past and evolves over time.*
- *…*

In secondary education:

- *Within a given problem statement, students will explain the influence of their own place attachment and that of others on historical imagery.*
- *Students analyse interactions within a building and between a building and its environment. (e.g. techniques to regulate the flows: Insulation, ventilation…)*
- *Students will explain the meaning and importance of sustainable development.*
- *…*

Knowledge about strategies for change

In primary education:

- *Students are able to illustrate the ways in which international organisations strive to promote well-being and/or peace in the world.*
- *Students can use an example of their own to indicate the usefulness and importance of a collective facility provided by the government.*
- *Students can explain in a simple way that elections are a basic element of the democratic functioning of our institutions.*
- *…*

In secondary education:

- *Students distinguish 'having a say', participation and decision making in school situations, taking into account the rights and obligations of all.*
- *Students illustrate the importance of individual and collective action and commitment to society.*
- *Students go through a problem-solving process that integrates knowledge and skills from multiple STEM disciplines.*
- *Students adopt health-promoting behaviours within the school context from an understanding of the importance of prevention and potential risk factors.*
- *Students illustrate how to engage and take action individually and as a group member on local, regional, national, or global issues.*
- ...

Action-oriented knowledge in LORET-inspired teaching practices

After addressing enabling conditions and obstacles in the institutional context of Flemish education, we now move on to investigate whether and, if so, how the tools, assignments and exercises in the LORET methodology can support teaching practices that facilitate the acquisition of action-oriented knowledge.

As argued above, with the transactional learning theory (Van Poeck and Östman 2021) we study the practice of teaching as encompassing both the preparatory work for planning and designing lessons as well as the actual implementation of the prepared lessons. However, because of delays due to restrictions related to the Covid-19 pandemic (see below) we have not been able to collect sufficient useful data about the performance of lessons. As a result, our analysis will focus on the preparatory work of teachers. In particular, we will use examples of pilot school 4 to illustrate how the tools, assignments and exercises in the LORET methodology influence the scripted purposes for the lessons, the scripted roles of students and teachers, the staging of a 'scene' (i.e. which certain objects / phenomena are brought to students' attention), and the staging of 'tasks' (i.e. how the students actively engage with the objects of attention). We then analyse to what extent and how the scripted purposes and roles as well as the staged scene and tasks contribute to teaching and learning a wide landscape of action-oriented knowledge.

Scripted purposes

We observed in pilot school 4 how the LORET concept, tools (scales) and exercises related to 'didactical carving' (see above: turning societal problems into a 'manageable' and 'authentic' challenge for the students to address) affected – as intended – the scripted purpose of the LORET plan. Together with the input of content experts, i.c. the biodiversity analysis offered by the environmental education centre, it brought the school team to formulate the overall purpose to take the students along in a quest for how to attract animals on and around the school campus that are no longer common in nature.

Scripted roles

As indicated, the LORET workshops strongly emphasise the importance of designing lessons that do not provide students – as passive 'objects' – with all the answers but that take them along – as active

subjects – in a problem-solving process. We have already illustrated above (see 'Overcoming disturbances' – 'Interventions of LORET workshop facilitators') how the interventions of the LORET workshop facilitator in this pilot school encouraged the participants to consistently consider that in their preparatory work: *'[Do] you see opportunities for the students to play a role in that?'*, *'Do you see opportunities to investigate this together with children?'*, etc. In this school, this aligned well with their habitual way of working.

The school team explicitly scripted an active role for the students which is, for example, reflected in the following quotes from teachers:

> *- Principal: 'We then start from the animals and habitats, and on this nature corridor we contribute our share as a place of residence for the crested newt. I see a lot of possibilities, and I think there's a lot of interest from the children.'*
> *- Teacher: 'I agree, and then also include the vegetable garden: what plants do we plant and what plants can we put together, and integrate all that. And I think a 2.5-year-old pre-schooler can also do something with that and feel: I'm* doing *something.'*
>
> *'I think this project is an eye opener, and I think it's very cool that it can be done. There are several children here who are very concerned about nature, and everything that has to do with animals. […] It's tangible, something you can* do*, so there's a lot more engagement than when you let them read something.'*

This active role for the students is also reflected in how a MOS coach stressed the potentiality of the emerging lesson plans to contribute to the curriculum goal: *'The students can give suggestions for designing their own environment.'*

Staging of a scene

The assignment and workshop exercise to make an inventory of useful resources for supporting the students' problem-solving process affects the staging of a 'scene' in the sense that teachers, with the help of the MOS-coaches (see above), identify content, objects, places, people, phenomena, etc. that they aim to bring to the students' attention throughout all four phases of a problem-solving process. A selection of what they mentioned in the preparatory assignment:

- Exploring the problem: parents or neighbours with knowledge on local biodiversity, biotopes, plants, animals, school campus, maps, nature reserves close to the school, nature guides, environment surrounding the school campus, etc.
- Generating possible solutions: adaptation of animals to their surroundings, food cycle, professions that are relevant for biodiversity, impact of weather/climate, nature conservation organisation, existing subsidies for greening school yards, organisation for ecological gardening, etc.
- Implementing solution proposals: natural materials, tools, technical design manuals, communication channels, awareness raising, nature management, bird nest boxes, insect hotels, school's vegetable garden, etc.
- Evaluating the problem-solving: identification cards, apps to identify species, characteristics to identify species, websites to monitor observations, field study materials, wildlife cams, etc.

Staging of a task

We also observed how the **whole-group discussion of the inventory of resources**, together with the fruitful **didactical carving exercise** in the previous workshop, gave rise to the staging of tasks for the students in line with the above-described purposes and roles. The LORET workshop participants jointly designed a **teaching activity that makes very concrete how to involve the students in the different phases of a problem-solving process**. They co-constructed an idea to walk from a nearby nature reserve where the crested newt (an endangered species) lives, all the way to the school (2km) looking for possible interventions that make it easier for the salamander and other amphibians to reach the school as a stepping stone to another biotope:

> *- MOS coach 2: 'After a bombardment [during the war] there are more than a hundred bomb craters in Tommelen [**nature reserve nearby the school**], as a result of which there are now pools. And such a small area is now the largest population of crested newts in Flanders. If you put traps in those pools, there's a good chance you'll see them. In consultation with Natuurpunt [nature conservation organisation] **there is a possibility to see and possibly even hold the crested newt**. This is very comprehensible for students. It is also a large, colourful salamander. It is a rewarding species to work with.'*
> *- MOS coach 1: 'Do you see possibilities in that? His nickname is also the "water dragon" so that can be exciting (laughs).'*
> *- Partner (landscape architect): '**Very interesting to visit with the children**. When will it show up again?'*
> *- MOS coach 2: 'The first round of trapping is at the end of March, beginning of April. The second round is in June. But Natuurpunt also does walks in between, and put down traps to show the amphibian species.'*
> *- Partner (landscape architect): 'And **if we speak of the school being a stepping stone for the spread of the crested newt: what is the next stepping stone**?'*
> *- MOS coach 1: 'What the colleagues, who work intensively with those nature connections, are creating […] is a map showing the location of the schools and the nature connection that lies there. But I was thinking about it: it's interesting to see between which areas that connection lies. **It is interesting to investigate this** as a school, with the students, because that natural connection does not yet exist. […] **How can we now start working between those areas?** There are opportunities to investigate this. But it is so coincidental that that connection to nature runs just below your school [as the map shows], and we experience that at very few schools. […] So, it is realistic to attract him. Everyone dreams of starting to link those populations between those areas. That ambition is realistic. In general, you can say: with a low ambition we are already working on a perfect biotope for amphibians, and in the meantime, we dream of attracting more and more great crested newts.'*
> *- LORET workshop facilitator: '[…] It was also said: it would be interesting to further investigate that environment between two areas. Is that something where you see opportunities for the students to play a role in that?'*
> *- Teacher: 'Is the aim of the school or of this project to create the best possible biotope or are we really talking about placing that salamander here?'*
> *- MOS coach 1: 'You are not allowed to place it: it is an endangered species. […] So you have to give those species better chances by working on the ecosystem.'*
> *- LORET workshop facilitator: 'Do you see opportunities to investigate this together with children?'*

*- Principal: 'I certainly think so. **We have a lot of children in grade 5 and 6, but also in the younger grades, who find it really challenging to work on that**.'*

*- Partner (landscape architect): '**Maybe we should also take a look at how that salamander from Tommelen comes to us [the school campus], and what route it follows. Perhaps corridors are needed to get here more easily [...] I find that fascinating: to take the children for a walk from Tommelen to here through the field, and to say: "Here is a field, that is going to be harder." But I don't know what the preferred way is to get here**.'*

*- LORET workshop facilitator: '**That's interesting to find out together**. That's the kind of resources they need. If you prepare lessons like this for the students, **that's the kind of resource they need** when it comes to the phase of proposing solutions. In order to search for an ideal route, they need as a resource: what kind of route does that salamander prefer, and how can we redesign this route so that there is a better chance that it will find its way.'*

*- MOS coach 2: '**That know-how is present here in the [environmental education centre]**. Amphibians are heat-loving, so they need shelter to migrate, but also open areas. They are therefore less able to migrate through a forest. A few years ago, we entered into a partnership with a secondary school in [another town] that was located in a connecting area. Development works have been carried out [there], pools have been constructed and trees have been felled for the amphibians.'*

*- Partner (landscape architect): '**Maybe as a school we can also trigger the municipality**, to make tunnels, etc. And speed it up. On the school site itself here it will be a challenge to make a decent living place for the salamander. Because deeper in the area there is a depression. When it rains, there is also water so provided an extra landscape intervention there, you can easily get something there. But on the school grounds itself, in terms of standing water, it is very rare. **We don't have sewage here** either, which is a frustration of mine. So, under our depression is a concrete pipe with waste water. Creating a habitat here is a serious challenge. We will have to do serious field work.'*

- MOS coach 1: 'A wintering place can be a first step.'

*- Partner (landscape architect): '**We also have to be able to test whether there are results**. It is also interesting for the children: we made it; the salamander is here on our property. You should help with that.'*

*- MOS coach 1: 'You can easily keep up with the children: are there more observations of amphibians? **You can register that, and then they see an evolution.** You can also open it up to amphibians in general.'*

- Partner (landscape architect): 'Yes, yes, fine.'

Conclusion: LORET and the landscape of action-oriented knowledge

The **LORET** methodology, and especially its emphasis on the 'didactical carving' of manageable and authentic challenges and on selecting education content and planning activities throughout all four phases of a sustainability problem-solving cycle, **facilitates the teaching and learning of a wide range of action-oriented knowledge**. Thus, it can help to overcome the often observed pitfall in ESE that students become paralysed due to a sole focus on the existence and consequences of problems without giving them insight in alternatives and strategies for realising these (Jensen 2002, 2004). In the emerging[23] LORET plan of pilot school 4, all dimensions of action-oriented knowledge are covered:

[23] The team is currently working on the preparatory assignment of LORET workshop 3 – creating the first part of the LORET plan.

- Knowledge about the existence and consequences of the problem: the problem of biodiversity loss and its consequences in the local environment (e.g. crested newt as endangered species)
- Knowledge about its root causes: influence of spatial planning on fragmentation of biotopes (biodiversity analysis map), pollution related to waste water (lack of sewage), agriculture (fields as obstacles for amphibians), etc.
- Knowledge about alternatives and visions: creating nature connections (school campus as a stepping stone), nature management (nature conservation organisation, nature reserves), biodiversity-friendly gardening (school's vegetable garden), creating biotopes for specific species (amphibians' needs), etc.
- Knowledge about strategies for change: direct action (e.g. creating corridors for amphibians, monitoring evolutions) as well as indirect action (e.g. communication, awareness raising, action towards the municipality)

Synthesis of findings

Updating and differentiating SEAS concepts, tools, and methods

Our analyses of challenges and opportunities with regards to transformational engagement, scientific literacies, and motivation contribute to the further development of several SEAS concepts.

The enabling conditions and obstacles for action-oriented knowledge that we identified progresses insight into how open schooling can contribute to 'Scientific literacy as/for Societal Transformation'. What deserves further attention, both in the practice of organising LORET workshops and in research on LORET-based teaching and learning, is how to move beyond an individualistic focus in the domains of 'alternatives and visions' and 'strategies for change' and how to (support teachers to) integrate knowledge on the transformation of societal (socio-technical) systems.

Insight in how to teach and learn action-oriented knowledge can also contribute to creating knowledge on how to foster 'Agency' in relation to sustainability issues and the challenge of tackling them. In that respect, it will be interesting in the future to identify which types of 'agency expressions' (Engeström 2015) can be observed in classroom and out-of-school activities that result from the LORET workshops: Resisting change, criticizing the current situation, explicating new possibilities or potentials, envisioning new possibilities for the future, committing to concrete actions aimed at change, taking consequential actions for change.

Our findings show how LORET allows teachers to take their students along in a problem-solving process, starting from authentic and locally relevant sustainability challenges, and how this creates opportunities to foster a wide range of action-oriented knowledge. In that sense, LORET-based open schooling can be considered as one possible, fruitful way of implementing the SEAS concept of 'Democratising inquiry'.

Following Jensen's (2002, 2004) critique that ESE often fails to teach students a sufficiently wide landscape of knowledge, we suggest that a conception of 'Scientific literacy' in relation to

sustainability problems should encompass not only (natural sciences) knowledge about the existence and effects of the problem but also knowledge about root causes, visions and alternatives as well as strategies for realising change. Observing how LORET can facilitate the teaching and learning of these dimensions of action-oriented knowledge, we can conclude that the methodology can foster specific and often overlooked aspects of scientific literacy. We will elaborate further on this in the next chapter.

The findings emerging from our analyses of enabling conditions and obstacles for action-oriented knowledge progress insight into how open schooling can contribute to '**Action/engagement towards sustainability**' and how the LORET methodology can be employed to support teachers in the didactical work involved. Here, too, it is important to emphasise the need to move beyond solely individualistic approaches and take into account aspects of societal transformation.

The transactional teaching theory we used in order to reveal the 'dramaturgy of teaching' (scripting, staging, performance) in LORET-based open schooling is well suited to be combined with transactional learning theory (see above: Chapter 1) in order to gain detailed insights in something that often remains black boxed in research on ESE: teachers' influence on students' '**Meaning-making and sense-making**' and the '**Learning trajectories**' emerging from that. As explained, we have not yet had the opportunity to sufficiently investigate the performance of the lessons designed through LORET workshops. It is a promising pathway for future research, however, to reveal the specific meaning/sense-making and learning trajectories emerging from open schooling and to identify patterns and conduct comparisons that allow us to further develop knowledge that can offer didactical guidance for teachers.

Conceptual model(s)

A model that allows us to address and further develop central SEAS concepts such as 'Scientific literacy as/for Societal Transformation', 'Agency', and 'Action/engagement towards sustainability' is Jensen's (2002, 2004) **model on action-oriented knowledge** (see above). Covering the wide landscape of action-oriented knowledge, Jensen (2002, p. 329) emphasises, has 'significant consequences for planning, implementing and evaluating teaching and learning'. With the above described analyses, we have shed light on what this implies in terms of teachers' didactical work of 'scripting, 'staging' and 'performing' lessons as well as on how LORET can be helpful to support teachers in this challenge. We also identified the potentiality and limits of the Flemish curriculum to enable or encourage this.

A much-needed pathway for future research, we believe, is to **further develop Jensen's model beyond a solely cognitive focus on knowledge**. As elaborately argued in research on ESE (e.g. Van Poeck et al. 2019), equipping students to cope with sustainability issues also involves other-than-cognitive – i.e. ethical, political, practical, emotional, aesthetical, bodily, etc. – dimensions. Inspired by Nussbaum's (2011) capability approach, we might think of developing a revised model of '**action-oriented capabilities**'.

Identifying Dilemmas

Also this chapter will be concluded by synthesising our findings in relation to a topic of debate in education research, that is, the tension between the risks and potentiality of engaging with real-world sustainability problems in education (Van Poeck and Östman 2020). We outline possible pitfalls and argue how (LORET-based) open schooling also brings about unique pedagogical opportunities.

In the pursuit of sustainable development, a lot of hopes are pinned on learning and education. The transition towards a more sustainable society is often described as a matter of 'learning by doing' and 'doing by learning' (Van Poeck et al. 2020). In several global policy initiatives, schools and universities are attributed a leading role in view of devising solutions for sustainability problems: The United Nations' 'Decade of Education for Sustainable Development' (ESD), UNESCO's 'Global Action Programme' on ESD, the Sustainable Development Goals (SDGs), etc. This trickles down into curricula, learning objectives, syllabuses, textbooks, classrooms practices, etc. worldwide and also among teachers, there is a broad consensus that sustainability issues require substantial attention in education (Yavetz et al. 2014; Tomas et al. 2017). Furthermore, students are also concerned about socio-ecological problems (Ojala 2013, 2016, 2019). Through 'school strikes for the climate' they not only urge decision-makers to take far-reaching action; they also explicitly question the usefulness of education as long as their concern for the climate crisis is not taken seriously. As teenage activist Greta Thunberg (2019) argues, they strike now because 'there is simply not enough time to wait for us to grow up and become the ones in charge'.

In contrast to this appeal to education to contribute to tackling sustainability problems, the relation between education and societal transformation has been the subject of a long-lasting, lively discussion in educational scholarship (e.g. Dewey 1916, Arendt 1961, Freire 1972). Contemporary educational researchers engage in nuanced criticism of the tendency to translate social and political problems into issues that need educational solutions. They argue, for instance, that such an instrumentalization of education threatens the democratic potential of education (Masschelein and Simons 2010, Säfström 2019) and values such as freedom (Biesta and Säfström 2011), pluralism (Todd 2010, 2011) and opportunities for young people to initiate newness (Biesta 2012). In response, Masschelein and Simons (2013) emphasise the importance of preserving the school as 'free time' – one of the meanings of the ancient Greek word *scholè* – for study and practice. 'In defence of the school', they argue for establishing a time and space where demands from outside the school are suspended, placed between brackets. They criticise approaches of the school as a place to remedy societal problems. Doing so, they argue, implies holding the young generation responsible for realising the political dream of another, better society and is an expression of an irresponsible society where the old generation passes the burden that it is no longer able or willing to bear to the students. It is from this perspective striking and painful to witness the young generation today sacrificing its own free to strike for the climate and, at the same time, challenging the old generation's illusion that they can pass the burden: 'People always tell me that they are so hopeful that young people are going to save the world, but they are not', Thunberg argues, as there is no time to wait for them.

The discourse of 'education as a cure' (Todd 2016, p. 843) has also been criticised in ESE literature (e.g. Öhman and Östman 2008, Ferreira 2009, Wals 2010, Garrison et al. 2015, Van Poeck et al. 2016). Already decades ago, Jickling (1994) wrote about 'Why I Don't Want my Children to be Educated for Sustainable Development' and argued that 'education is concerned with enabling people to think for themselves' and that 'education for sustainable development … or education "for" anything else is inconsistent with that criterion'. Ever since, ESE scholars have argued that education needs to be something more than a 'problem solver' (Van Poeck and Lysgaard 2016) and an instrument that services ethical or political goals established from outside its practices (Todd 2016).

Being faced with this tension, the response to it should according to Van Poeck and Östman (2020) not be sought in an either/or approach. It is not a matter of *either* prioritising engagement with sustainability problems and thereby falling into the instrumentalization of education, *or* choosing for democratic education, freedom, pluralism, newness, and creativity by banning the quest for solutions for sustainability problems from the school. A more relevant question that arises is how we can think and design education so that students can engage with urgent and severe sustainability challenges without being reduced to instruments for externally determined demands. The reasoning behind that, is that addressing real-world problems in education brings about unique pedagogical opportunities.

LORET is designed to offer didactic support for educators to teach in a way that simultaneously takes both above described concerns into consideration and, thus, to act in accordance with a twofold pedagogic responsibility. Masschelein and Simons (2013) have strikingly captured this responsibility in the metaphor of the teacher that brings something to the table and lets it go, makes it free. Drawing on the writings of Arendt (1961), they call on teachers to act 'out of love for the world ("this is important to us, the old generation") as well as out of love for children ("it is up to you, the new generation, to shape a new world")' (p. 87). From this perspective, we consider both options within the above problematized either/or approach irresponsible. Banning the concern for sustainability problems from the classroom can be seen as failing to bring something to the table and, thus, to take responsibility for the world and, thereby, also for the students. It means giving students the message that 'I don't know what is important, I cannot and will not tell you, so figure it out for yourselves' (Masschelein and Simons 2013, pp. 86-87). 'How can [students] renew the world', the authors wonder, 'if no one actually introduces them to the old world and brings the old world to life?' Yet, they emphasise, 'this also means that the teacher must let go of and make free whatever she brings to the table', so that the students can give their own meaning to it. This is very different from designing education instrumentally with the intention to teach students how they are to act in the future, which would deprive them from their own opportunity to renew the world (Lilja 2018). Bringing something to the table and making it free are thus two inseparable aspects of the teacher's pedagogic responsibility. Two vital didactical questions arising, then, are *what* to put on the table and *how* to make it free. LORET, with its focus on 'didactical carving', on identifying useful resources for the students' inquiry, and with its ambition to let the students themselves generate and experiment with novel solution proposals aims to support teachers in coping with these questions.

In that sense, **LORET-based open schooling can allow teachers to grasp the unique pedagogical opportunities involved in dealing with real-world problems**: opportunities for teaching and learning specific knowledge, insight and skills, for fostering creativity, for offering experiences of commitment and of being able to make a difference, for first-hand experiences of how different people may each have their own idea of how to solve the problem, for learning to handle resistance, etc. Considering the risks described above, it is important to realise that this pedagogical potential will not be automatically unlocked but requires specific 'didactical work' (Van Poeck and Östman 2020).

Reporting area 3, Belgium: Challenges and opportunities with regards to teaching and learning scientific literacy

Methods

Data sources and Participants

In the Belgian local network, we focus the assessment of challenges and opportunities with regards to teaching and learning scientific literacy on how LORET-based open schooling (see above) approaches and fosters scientific literacy.

We conduct qualitative analyses of workshops with teachers and education activities and collect data from the following sources[24]:

- Video- and audio-recordings of classroom activities
- Video- and audio-recordings of out-of-school activities
- Video- and audio-recordings of meetings + transcripts
- Video- and audio-recordings of LORET workshops + transcripts
- Field notes of meetings and LORET workshops
- Video- and audio-recordings of interviews with teachers + transcripts
- Documents (for content analysis): policy documents (curriculum goals), LORET plans, LORET workshop assignments, lesson plans, teaching materials, student work, emails, etc.
- Research literature

Analytical procedure and approach

Our overall research question is: How is scientific literacy conceived and fostered in LORET-based open schooling?

We address this overall question through the following sub-questions:

1. Which kind of scientific literacy is important to enable students to engage with sustainability problems?
2. Which vision(s) on scientific literacy can be identified in the Belgian open schooling network?
3. What are enabling conditions for open schooling to foster that kind of scientific literacy?
4. What are obstacles for fostering that kind of scientific literacy?
5. What is the influence of the institutional context?
6. What is the influence of teachers' practices?
7. What is the influence of LORET workshops and assignments?

Theoretical framework

[24] The data-set is described in detail in Chapter 1 and 2.

For our qualitative analysis we use a framework that has been applied earlier in research literature: three visions on scientific literacy. Roberts (2011) describes the school curriculum as 'an object of political and professional struggle' (p. 11) and distinguishes between two fundamentally different, broad[25] visions on scientific literacy: Vision I and Vision II. In doing so, he draws attention to the *substance* of curriculum policy as it is reflected – and encountered by teachers – in a required set of learning outcomes, a syllabus, a textbook, etc. Vision I and II have their roots in two competing curriculum sources; (I) internal: the discipline of science itself, the products, processes, and characteristics of the scientific enterprise, and (II) external: situations in which science demonstrably plays a role in human affairs. Distinguishing the divergent characteristics of both visions, Roberts argues, is important to avoid confusion that can occur if the term 'scientific literacy' is used to refer to the whole array of long-term outcomes of school science associated with both visions. Vision I and Vision II 'envision' the scientifically literate person – and what that person should know and be able to do – in very different ways. In both visions, students will learn the scientific meaning of concepts, laws, theories and procedures but they will do so with a different *purpose*.

Vision I, as argued, focuses on the internal aspects of the discipline of science itself and thus envisions the scientifically literate person as someone who understands key concepts and principles of science, is familiar with the scientific process and method, has acquired inquiry skills, uses scientific knowledge and ways of thinking, etc. Curriculum policies in line with this Vision I are, according to Roberts, oriented towards developing a pool of potential scientists. This logic of scientific literacy as a matter of getting students 'ready for the next course' (Roberts 2011, p. 14) brought Sjöstöm and Eilks (2018, p. 78) to label Vision I as 'pipe-line science'. It is 'about learning about scientific content and scientific processes *for later application*' (p. 65 – our emphasis). Thus, the assumption is that if students acquire the necessary, basic scientific knowledge and skills, they will be automatically able to apply it for individual and social purposes. The focus is epistemological, and explicitly limited to that. As Östman (1996) argues, an abundance of things is said and done during any lesson. It is impossible for the students to learn all of that – and this is also not what the teacher expects. S/he wants the students to pay attention to the essentials and thus prepares and performs lessons that try to govern students' attention to this 'primary focus' (Östman 1996, p. 40) of the teaching. To refer to this primary focus, Östman introduced the concept of 'subject focus'. Drawing on the work of Fensham (1988), he labels the subject focus that characterises Vision I as 'induction into science'. The primary object, the aim for the students is to learn general scientific knowledge. Phenomena and events in the world are thereby used in an illustrative way, i.e. as instruments for the students to learn the concepts of the natural sciences. They are, so to speak, reduced to 'means' for the 'end' that is internally situated in the discipline of science itself.

Vision II has, as indicated, an external focus. It envisions the scientifically literate person as someone who is able to, for example, appreciate and understand the impact of science and technology on our lives, to take informed personal decisions about topics that involve science, to understand media

[25] The visions, Roberts (2011, p. 12) argues, orient us in broad and general terms (e.g. 'more *like this* than *like that*') and are in that sense a 'pointer' rather than 'a pigeon-hole system for classifying definitions'.

reports about issues that involve science, etc. (Roberts 2011). Again, it is obvious that here, too, the students are expected to learn scientific knowledge. Yet, the focus is not limited to this but explicitly expands towards how science plays a role in human affairs. Östman (1996, p. 41), referring to Fensham (1988), has called this subject focus '**learning from science**', characterised by the use of natural science concepts to explain phenomena and problems arising when human beings interact with nature. Instead of pipe-line science to prepare future scientists (Vision I), this focus on usefulness reflects an idea of 'science for all' (Sjöstöm and Eilks 2018, p. 78).

Several authors (e.g. Osborne 1998, Aikenhead 2007, Sjöstöm and Eilks 2018, Östman 2021) have emphasised the need to add a **Vision III** on scientific literacy. Focusing on so-called 'socio-scientific issues' (SSI) (Zeidler and Sadler 2011) and what it requires from a scientifically literate person to deal with these, this third perspective expands the focus from 'science for all' to 'science for transformation' and engagement in socio-political action (Sjöstöm and Eilks 2018, p. 78). This expands the focus of Vision II from 'learning from science' in order to understand and be able to handle everyday and technological sustainability problems towards **'learning from science' in order to understand and be able to handle the ethical and the political dimension of sustainability problems** (Östman 2021 – personal communication). Here, the scientifically literate person is envisioned as someone who is able to critically reflect on societal issues involving science, to take part in discussions on it, to use scientific insights for suggesting proposals to solve societal problems, to do so while taking into account concerns for democracy and justice, etc.

Methodology

We use **thematic analysis** to analyse documents (policy documents on curriculum goals, LORET workshop assignments, LORET plans, lesson plans, teaching materials, etc.) as well as transcripts and field notes of observed LORET workshops and lessons guided the above elaborated theoretical framework.

With our analysis, we **specify which vision(s) on scientific literacy can be identified in LORET-based open schooling** and what how this affects how sustainability challenges are addressed (question 1 and 2). Therefore, we draw on the same empirical examples from pilot schools 3 and 4 as analysed in the previous chapter. The findings described there will also inform the here presented analysis of challenges and opportunities with regards to teaching and learning scientific literacy, as a way of further deepening the insights elaborated in the previous chapter. In order to **identify enabling conditions and obstacles for fostering scientific literacy** (question 3 and 4), we conduct the following analyses:

- Scrutinising policy documents in order to **screen curriculum objectives** with regard to whether/how they address Vision I, II and/or III on scientific literacy[26] (question 5).

[26] Due to the challenges involved in an unambiguous understanding of the Flemish curriculum goals (see above), we opted for researcher triangulation (Patton 2002) and involved two different researchers (i.c. Katrien Van Poeck and Leif Östman) in screening the targets and discussing the results.

- Scrutinising the data looking for empirical evidence of how **teachers' preparatory work of designing LORET lessons** (i.e. their scripting and staging) reflect Vision I, II and/or III on scientific literacy (question 6).
- Scrutinising the data looking for empirical evidence of the **influence of LORET workshops and assignments** on how teachers' approaches to scientific literacy (question 6).

Findings

Scientific literacy in the Flemish curriculum

We screened the attainment targets in order to find out **to what extent the three different visions on scientific literacy are reflected in the curriculum goals**. As also explained in both previous chapters, we focused on the 'soberly formulated' attainment targets since we cannot systematically screen all the different curriculum plans. Here, too, this implies that it was often not possible to unambiguously connect the targets to the different visions because a lot depends on the concrete operationalisation in various contexts.

In the Flemish curriculum, we found many examples of final attainment targets that reflect **Vision I with its 'induction into science' focus**. It **is the dominant vision** within the Flemish science education curriculum. Some examples:

- *'Under supervision, students can test at least one natural phenomenon that they observe against a hypothesis through a simple investigation.'*
- *'The students appreciate mathematics as a dimension of human inventiveness.'*
- *'The students can explain physiological processes on the basis of the structure and functioning of the involved organs in humans.'*
- *'The students can use the IUPAC naming convention for inorganic substances.'*
- *'The students can apply lab skills to collect reliable information.'*
- …

There are clearly **much less examples of final attainment targets that reflect Vision II** although we did find some, for example:

- *'The students can administer basic aid in case of burns.'*
- *'The students can analyse thermal properties in view of the insulation of buildings.'*
- …

We found **some examples of final attainment targets that reflect Vision III**, for instance:

- *'The students can give suggestions for designing their own environment.'*
- *'The students can use presented strategies to enter into a dialogue about societal challenges in an informed manner.'*
- …

Scientific literacy in LORET-based open schooling

LORET, with its focus on realising curriculum goals through engagement with real-world problems, is designed in line with the **philosophy of 'learning from science'**. Our analyses presented in the

previous chapters reveal the methodology's potential as **a vehicle to support teachers in implementing Vision II and III**. We will substantiate this with examples described in Chapter 2.

Our findings illustrate the above emphasised assumption in science education research literature that, also in Vision II and III, **students learn scientific knowledge and procedures**. For example:

- *'Students know the vocabulary related to water scarcity and water footprint'*
- *'Recognising the horizontal and vertical relationships that explain water scarcity in the studied region'*
- *'Displaying values correctly in calculations, taking into account significant figures'*
- *'Applying the efficiency of energy conversions qualitatively and quantitatively'*
- *Knowledge on biotopes and characteristics and needs of certain species*

What distinguishes an 'induction into science'-focus from a 'learning from science'-focus is, as indicated, that they do so **with a different *purpose***. We found many examples of scripted purposes and corresponding didactical choices of content and activities that reflect a focus on **'learning from science' in order to understand and be able to handle socio-political, real-world problems** (Vision III). For instance:

- *'In clarifying and seeking solutions to sustainability issues, apply scientific principles related to resource consumption, energy use and the environment'*
- *'The students can give suggestions for designing their own environment.'*
- *'Students write […] a concrete, numerically substantiated report for the school management to defend the necessity of water storage and use'*
- *'Students find out for themselves what could be done with the rain water falling on the school campus'*
- *Creating nature connections*
- *Awareness raising*
- *Taking action towards the municipality*

These purposes, content, and activities are chosen in view of offering the students possibilities to grow as scientifically literate persons who are able to use scientific insights for suggesting proposals to solve sustainability problems, to critically reflect on and discuss societal issues, etc.

We also observed that some lessons in the LORET plans are focused on **'learning from science' in order to understand and be able to handle everyday and technological sustainability problems** (Vision II).

- *'Students know their own water consumption and can quantitatively link that water consumption with different needs.*
- *'Students find out what is included in the cost of water storage: distribution, filtering, storage, inflation…'*
- *'Students calculate their own water footprint'*
- *'Students monitor the water consumption in their own home for a week (check meter)'*
- *'Making a water filter'*
- *Building bird nest boxes and insect hotels*
- *Growing vegetables*

Here, the purposes, content, and activities are chosen in view of offering the students possibilities to grow as scientifically literate persons who are able to take informed personal decisions about topics that involve science, understand the impact of science and technology on everyday phenomena, etc.

Synthesis of findings

Updating and differentiating SEAS concepts, tools, and methods

Our analyses of challenges and opportunities with regards to teaching and learning scientific literacy contribute to the further development of several SEAS concepts.

One of SEAS' main concepts is '**Scientific literacy**'. We have shown how LORET-based open schooling reflects a vision on scientific literacy as 'learning from science', both for handling everyday problems and for engaging with socio-political issues and societal transformation (Vision II and III), and how LORET can support teachers to implement this.

In the philosophy of LORET, with its interest in offering students unique educative opportunities such as experiences of commitment, resistance, conflicting values, divergent ideas about how to solve a problem, etc., (science) education is more than only transferring scientific facts but also exposes students to sustainability challenges as '**Socio-scientific issues**' in view of progressing their capacities to handle their ethical and political dimension or, in other words, their '**Complexity/wickedness**'. More research is needed in the future to gain more insight into what students learn in this respect in the performance of LORET-lessons. Particular attention should be paid to how this contributes to students' '**Critical thinking**' and '**Reflexivity**' as important characteristics of a scientifically literate person according to Vision III.

Conceptual model(s)

Vision I, II, and III on scientific literacy (see above) provides us with a suitable model for understanding and investigating scientific literacy in the context of open schooling and sustainability. Based on our analyses presented in this report, we can conclude that the LORET methodology is a fruitful vehicle for supporting teachers in the didactical work involved in implementing Vision II and, especially, Vision III in the design of their lessons.

Several promising **pathways for future research** remain un(der)explored. First, as argued above, it is important to trace connections between teaching practices inspired by 'learning from science' and the **students' learning** that takes shape through these activities. Second, it would be interesting to identifying **specific 'subject foci'** that become actualised in open schooling. Östman (1996) distinguishes 'induction into science' and 'learning from science' as broad categories but identified, based on a detailed study of chemistry textbooks, four different, more specific subject foci in the latter category: 'Exploitation of Nature focus', 'Human Beings as a Threat focus', 'Survical of Homo Sapiens focus', and 'Preservation of Nature focus'. An analogous investigation of subject foci specific to open schooling – instead of chemistry textbooks – combined with identifying the teaching

practices that are conducted to implement these and how these affect students' learning would progress our understanding of teaching and learning scientific literacy through open schooling.

Identifying Dilemmas

As in Chapter 1 and 2, we will conclude by positioning our analyses and findings in relation to dilemmas and tensions addressed in the wider research field. An interesting and relevant framework to do so, is the distinction between three so-called 'selective traditions' in environmental and sustainability education (Sandell et al. 2005, Öhman 2008, Öhman and Östman 2019): a fact-based, normative and pluralistic tradition. Historical didactic research shows that there are different traditions in selecting teaching materials and methods. Williams (1973) called these 'selective traditions' and emphasised that the approach to knowledge and to educational practices is always chosen (selected) within the framework of a particular culture. Over time, the developing selection patterns form a selective *tradition*. Each tradition represents specific answers to the question of what is the best teaching method for a subject/theme/content and includes a number of specific approaches and choices in teaching content and teaching methods.

In the fact-based tradition, sustainability issues are regarded as knowledge problems: they arise because the public is ignorant and/or because we do not have the necessary knowledge to tackle problems in the most effective way. From this perspective, sustainability issues are issues for science – especially for the natural sciences. More research and technology and more information are assumed to lay the foundation for a more sustainable development. Educational practices therefore solely focus on transferring scientific models, facts and concepts – as is the case in Vision I on scientific literacy. There is a strong belief that only science and scientific facts form a reliable basis for knowledge about sustainability issues. From that point of view, only scientific facts and models are important in educational practices. It is expected that students themselves will draw the correct conclusions based on these facts and act accordingly. Teaching is therefore strongly focused on transferring subject knowledge, often through teacher-led lessons. In this tradition, facts are strictly separated from values. The latter are regarded as subjective, as belonging to the private sphere of the students and therefore as something that cannot be discussed in rational discussions. Consequently, ethical and political aspects are considered as something that has no place in education. Objective education is paramount and it is not seen as the school's job to influence the ethical and political views of students. The guarantee of such objective education is a focus on teaching facts based on scientific knowledge. The underlying idea is that scientific research is a value-free, neutral practice and that science can provide us with the necessary knowledge to solve sustainability problems. In this sense, the democratic role of education is limited to offering objective facts on the basis of which students can form an opinion afterwards. By acquiring more knowledge, the students are assumed to be gradually enabled to fulfil their democratic rights as citizens.

Within the normative tradition, sustainability issues are primarily regarded as moral problems that can be solved by adopting environmentally friendly and sustainable values, norms and lifestyles. These values and norms are based on scientific knowledge. In this way, science is seen as a practice with ethical implications: from the facts that science provides us, it can be deduced what the correct

values and standards are for sustainable development, the reasoning goes. If people act accordingly, the whole society can be reformed in accordance with scientific knowledge and predictions. This philosophy is also known as 'scientism'. According to this tradition, experts from various fields should advise people and guide their choices. Adopting an eco-friendly lifestyle is seen here as an individual responsibility. In this tradition, the answers to value-laden sustainability issues arise from discussions between experts and policymakers based on scientific facts. These are then translated into the curriculum. This is based on the assumption that it is possible to find universal solutions for sustainability issues. Schools are expected to teach sustainable values and standards in order to steer the behaviour of the students in the right direction. Key ambitions here are to engage students in sustainability issues, encourage responsible behaviour and teach practical skills to apply theoretical knowledge in practice. Although the lessons are based on scientific facts, values and emotions are also considered important for promoting engagement.

Central to the pluralistic tradition is the increasing uncertainty about sustainability issues and the proliferation of differing opinions in the debate on them. Sustainability problems are seen as political issues: conflicts between different interests, values and ideologies. Different groups with equally differing values and perspectives have divergent views about what the problem is and how serious it is. Even when one agrees on the facts, the reasoning goes, one can have differing ideas about what is the best approach to sustainable development based on divergent ideological convictions. Because science is limited to providing facts, it is not seen as the one and only source of guidance when it comes to ethical and political aspects of sustainability issues. This tradition strives to highlight different, sometimes conflicting, perspectives, visions and values about the future of our world. In contrast to the fact-based tradition, it is assumed that not only facts but also values and emotions can be the subject of rational discussions. These are open-ended and do not target predetermined ideological positions. Much emphasis is placed on developing a shared understanding of how to use facts for making choices and judgements, recognising and accepting different points of view, and democratic discussion. The latter is seen as an essential part of education in the pluralistic tradition. The aim is to provide students with competences to critically evaluate different perspectives and to take a stand in debates and decision-making at both the private and societal level. Discussing a wide range of points of view is seen as an important aspect of ESE. This aligns well with Vision III on scientific literacy.

LORET-based open schooling, with its ambition to take students along in an authentic, open-ended quest for solutions for sustainability problems and to let them explore a diversity of options, opinions, perspectives, preferences, etc. can obviously be understood as ways to operationalise and implement pluralistic sustainability teaching.

COVID-19 Impacts

The Belgian SEAS open schooling network has been affected by the Covid-19 pandemic and the measures taken to cope with it. Covid-19 restrictions have impacted educational practices during many months in the period of our local assessment. Lessons have been moved from on campus to online (especially in Spring 2020), contacts with non-school partners have been limited in several phases of lockdown, excursions were cancelled, externals were denied access to schools, meetings had to take place online, etc.

Obviously, this also had an impact on our activities in the open schooling network as well as on our assessment. Our data collection has been delayed, especially with regards to observations of classroom practices and out-of-school activities. As we explained above, our response has been a shift in focus of the assessment from the implementation of education activities towards the preparatory work of planning and designing lessons. Many of the LORET workshops (in some schools even all of them) had to take place online. Although this has some disadvantages such as lacking the possibility to explore the campus and school yard or to experience the atmosphere in a school, the digital format worked well and allowed us to experiment with tools and approaches that might increase efficiency of future (post-pandemic) workshops. A less clear-cut, but perhaps the most far-reaching impact of the Covis-19 crisis, is how teachers, principals, non-school partners – just like probably many other actors in society – where overwhelmed by a massive disturbance of their usual practices, both professionally and privately, which resulted over time in what we could call a chronical state of exhaustion. In this context, we did not find many teachers and schools able and willing to take on new, challenging projects and tasks. As indicated, this resulted in reconsidering the initially planned collective LORET workshop in collaboration with PNC and turn it into a collaborative intensive trajectory with only one pilot school in view of generating ideas and guidelines for how environmental education centres and other intermediaries can (collectively or individually) support schools.

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4. Estonia local assessment

Reporting area 1, Estonia: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface

Energy Discovery Centre (EDC), a science centre based in Tallinn, Estonia, can be categorised as a non-formal learning environment based on the definition set by the OECD[1]. The Centre's interactive exhibitions and educational programmes have been designed to support and complement the national school curriculum in natural sciences and also cross-curricular topics (Lifelong Learning and Career Planning; Environment and Sustainable Development; Health and Safety; Technology and Innovation etc). Though the students' learning process is guided in the Centre, the programmes are not a part of the formal education system; rather, schools and teachers have the opportunity to choose the Centre's programmes as an extra learning experience for their students. On the other hand, the learning process is not entirely informal, as it is intentional and organised with manifested learning objectives.

Generally, EDC's educational programmes are short one-time interventions (30-90 minutes in duration) for students from primary school up to the end of secondary school (approx 7-18-year-olds). Although schools have different approaches, usually the average pupil in a Tallinn school would have been to a class visit to EDC about once a year.

On the other hand, schools and teachers have requested longer and more in-depth education programmes (especially to support the learning of Physics as a school subject) in an out-of-school context. In previous focus group interviews conducted by EDC, teachers have expressed a need to integrate schools subjects more cohesively (e.g an atom discussed in Chemistry class is the same atom under scrutiny in Physics and Biology classes), and that EDC as an environment can add to the students' learning trajectories. In addition, the local municipality, the City of Tallinn, has a policy of fostering "learning everywhere" to support both non-formal and informal learning opportunities[2].

In a year, typically about 12,000-13,000 students take part in EDC's educational programmes, with the exception of 2020, when participation dropped to about 7,000 due to recurring COVID-19 restrictions. In a sense, EDC is already part of an open schooling network with a number of schools locally (and nationwide), a network of individual teachers (communicated with via newsletters and events), and interested parents (via EDC weekend events), EDC typically designs its educational programmes to be closely the national curriculum and EDC's educators have a background and/or recent experience of teaching science at school. Although school groups are asked to test the programmes and teachers give feedback for the next iteration, that is usually the extent of network partners' contributions to the teaching plan. Within the scope of the SEAS project, however, EDC set out to 1) open up its education programme design process to include traditional

and nontraditional stakeholders from its network in a more straightforward manner, and 2) test different methods of teaching and learning science.

For the SEAS project, EDC zoomed into a smaller, but more diverse open schooling network to co-design a longer and in-depth intervention ('pilot project') in the form of extracurricular science classes ('Science Club') with weekly meetings throughout a school year, following a curriculum-based teaching plan with a focus on locally relevant sustainability issues. EDC issued an open invitation for collaboration in its schools' network and two Tallinn schools welcomed the opportunity to co-design the Science Club for their students. The Science Club began on 1 October 2020 with an introductory meeting open for all interested, and continued from 6 October until 26 May 2021. Stakeholders invited to co-design the Science Club met between January 2020 and October 2021.

Methods

Data sources and Participants

In the Estonian local network we focused on the challenges and opportunities of establishing and implementing open schooling partnerships by co-designing an extra-curricular Science Club. The stakeholder groups incorporated to the Estonian local network were:

- The local municipality - the city of Tallinn, represented by the Urban Environment and Public Works Department
- 2 municipal schools
    - Tallinna Nõmme Põhikool (elementary school, grades 1-9), represented by 1 teacher and 1 parent from the school's board of governors
    - Tallinna Ühisgümnaasium (secondary school, grades 1-12), represented by the school principal and 1 teacher
- National power company Eesti Energia AS, also a founding member of EDC
- SME, after-school activity provider - Bumble Erahuvikool
- SME producing sustainable fashion accessories based in Tallinn - Märss OÜ
- Non-profit organisation focusing on development cooperation, global education, and humanitarian aid - MTÜ Mondo
- Non-formal education centre - Energy Discovery Centre
    - Team lead, researcher: Krista Keedus
    - Researcher, editor: Teele Tammeorg (september 2019 - January 2020; September 2021 - December 2021)
    - Educators: Kerttu Voor, Jana Paju

Table 1 presents an overview of the data collected about the activities of the Estonian local network.

Stakeholders were contacted in autumn 2019. The initial idea of the pilot project and the framework of the SEAS project was introduced via emails which was followed by agreements made by phone, emails, face-to-face meetings, instant messaging etc. The EDC team planned to organise at least 4-5 co-design workshops ('ChangeLabs') with the stakeholders, with the addition of hands-on activities at EDC and opportunities to observe the Science Club activities *in situ*. The original plan, however, had to be revised repeatedly due to COVID-19 restrictions (see *4. COVID-19 impacts* p 31).

Table 1: Data collected in the Estonian local network

DATE (dd.mm.yyyy)	AGENDA	PARTICIPANTS	DURATION, PLACE	DATA SOURCE
28.01.2020	ChangeLab 1 Preparatory co-design meeting:	Stakeholders (n=9)	2 hours, EDC	Presentations, minutes, field notes
Preparation of preliminary teaching plan, first draft ready.				
14.08.2020	Discussion on preliminary teaching plan	EDC educators (n=3)	4 hours, EDC	Memo
08.09.2020	ChangeLab 2 Co-design meeting to discuss and finalize the teaching plan.	Stakeholders (n=10)	2,5 hours, Zoom	Recordings[3] and transcripts, minutes
Email correspondence with schools. Science Club ran from 6 October 2020 - 26 May 2021.				
30.11.2020	ChangeLab 3 Overview of preliminary results of 1st Local Assessment (LA) and Global Assessment Instrument (GAI), discussion. Discussion on data-based decision making.	Stakeholders (n=8)	2 hours, Zoom	Presentations, recordings and transcripts, minutes
29.06.2021	Semi-structured interviews	EDC educators (n=2)	2 x 40 min, Zoom	Recordings and transcripts
16.09.2021	Reflection meeting	EDC researchers (n=2)	1,5 hours, EDC	Field notes
05.10.2021	ChangeLab 4 Overview of LA and GAI results, and Science Club meetings. Discussion and feedback.	Stakeholders (n=4)	60 min, Zoom	Presentations, field notes, minutes
03.11.2021	Reflection meetings	EDC researchers (n=2)	1,5 hours, EDC	Field notes

Analytical procedure and approach

In order to make observations about the challenges and opportunities regarding the establishing of open schooling networks, two research questions were posed:

- What are the positions and roles of different stakeholders in the Estonian local network?
- How did the positions and roles change in the course of the co-design process?

The EDC Team interpreted co-design as a dynamic process and creative open-ended process, based on the SEAS project deliverables D2.1 and D2.4, with leeway to redefinition and refocus as the process evolves. The co-design process was originally intended to work in iterations: two groups of students learning in the Science Club in parallel, a number of thematic blocks in the syllabus, after each a local assessment with potential changes in teaching plan with stakeholders, or indeed a different approach to ChangeLabs.

The LORET (Locally Relevant Teaching) tool was used to guide the co-design process of the teaching plan for the Science Club, but was not a focal point in this assessment. Drawing from D2.1 and D2.4, each ChangeLab meeting had an agenda (see Table 1). Meetings were recorded and transcribed, and *inductive thematic analysis* (Braun & Clarke, 2006) as a flexible method was used to analyse the discussion.

To illustrate the approach to facilitating ChangeLabs, here is an example from the kick-off meeting. Participating stakeholders were invited to introduce themselves and reflect upon their personal experiences with the formal education system and sustainability issues. The EDC team elaborated on each participant's connection with the Centre in order to inform the group as a whole (based on project deliverable D2.1: building upon existing synergies and identifying competencies,) The EDC team introduced the SEAS project and the idea for the co-design process to create a teaching plan for a Science Club, test the teaching plan and materials in two iterations (on 2 groups of students), and assess the intervention from the aspect of the collaboration process (1) and students' feedback (2) via Local Assessment (LA) and Global Assessment Instrument (GAI) procedures outlined in the SEAS project. In order to establish shared values and goals and to identify relevant sustainability challenges, a brainstorming exercise was organised in order to define and agree upon the aim of the Science Club.

The co-design process was affected by the COVID-19 pandemic shortly after, as the first ever pandemic lock-down was imposed on 12 March 2020 (see *4. COVID-19 impacts* p 31). From then on, all ChangeLabs were facilitated digitally (via Zoom) - at first because face-to-face meetings were restricted, later on because stakeholders asked for an opportunity to join via Zoom.

Findings

Establishing common values and goals

In order to establish shared values and goals and to identify relevant sustainability challenges, a brainstorming exercise was organised in the very first ChangeLab meeting (Q: What will be the most important sustainability issues our (7th grade) students will confront in their adulthood (in 2035)?). Stakeholders named a total of 27 challenges. Stakeholders were then asked to give 3 votes each to choose the most important issues (extinction of honeybees and other pollinators; urbanisation; shortage of drinking water). The issues deemed most important by the group were then compared to the Estonian long-term development strategy document "Estonia 2035". The attention to the problem of pollinators was in good correlation with the emphasis put in the strategy document, on the other hand, CO2 and other greenhouse gas emissions - though important issues for the city of Tallinn, Estonia, and the planet on the whole - were not mentioned at all in the group[4].

The challenge chosen by the group as being most relevant - the extinction of honeybees - was then further explored based on the scenario method outlined by Dale et al (2006). Stakeholders were asked to place the issue on an axis system (x= I know the scientific reasons - I don't know the scientific reasons; y= I am doing something about it - I'm not doing anything about it). The majority of answers were placed in the sector of knowing about the scientific reasons and doing something about it. As a result, the group defined the aim of the intervention ('Science Club'): to ensure students are aware of and understand the processes that cause various environmental problems and are willing to change their attitudes and behaviour in order to reduce the impact of problematic anthropogenic activity. In addition, four thematic blocks were agreed upon for the Science Club teaching plan: Biodiversity (derived from the issue of honey bees), Climate change (added), Energy (connected to the former), and Circular Economy.

Stakeholder roles and positions

Although determining common values and goals seemed generally an easy exercise with the stakeholders, the co-design process became more complex as time moved on. The analysis of meeting transcripts revealed many, sometimes conflicting themes. The positions of different stakeholder groups were heavily influenced by their role (teacher, parent, school leader etc), and therefore we categorise our findings based on stakeholder groups and give a short summary of each position with example quotations from the discussions.

Educators. They discuss the practicalities of fitting different activities into the timeframe of the Science Club, talk about methods, organising the students' transport to EDC and back to school etc. Their suggestions can be put to use immediately. They have a common 'language of education' and understand each other very well. Note: not all of them actually are educators, this group includes a wider range of stakeholders.

An example of such an interaction presents itself in the co-design process, when an EDC educator presents a first draft of the teaching plan to the stakeholders:

> *"[G]enerally the big topics are biodiversity, circular economy, energy, and climate change. And because we want to look at all these as broadly and deeply as we can, we have many activities planned. In addition, because we want to combine many different methods for the children, give them a lot of chances to reflect on what they have learned, then we're planning to have a student conference, if at all possible, and let them do poster presentations, in essence."*
> *[…]*
> *(Representative of the municipality:)"I can say right away that we can have the students take part in the Aegna nature house educational programme, and to get to Aegna [island] you have to travel over the sea and taking part is free for extracurricular activities. […,]*

The School Teachers. They shared the language and understanding with the educators-group described above. In addition, they were extremely busy, worrying repeatedly about time management and the extent of their involvement in the process.

> *"Perhaps very quickly, I have to leave very soon, and very quickly - my biggest concern is, of course, the Corona situation as well.. But my very practical question is that right now*

the classes are on two mornings a week, the first two lessons, how will this fit into the plan? I raised this [issue] at the last meeting as well, how does the timing work?"

In addition to worrying about their own and their students' time management, school teachers also suggested that the Science Club cover topics from the national curriculum so they would not need to cover those in regular classes.

The Non-Formal Partner. EDC was not the only non-formal education partner involved in the co-design process, but as the EDC educators would be leading the Science Club activities, The educators therefore offered definitions of what their and their institution's roles might be, often in comparison with the formal education system.

> "Often it's possible to go through lower secondary school without putting together electric circuits, you see, because there isn't that opportunity at school or the teacher cannot do it for some reason. Because we've thought it through for ourselves that it's important for us to be that good partner to a school, managing to do complicated things easier, and more fun, in a sense, but definitely different to how it's done at school, because we're essentially a different kind of institution."

The School Principal. Very supportive in his declarations, nearly always found time for ChangeLab meetings, but did not get involved in discussions about practicalities, delegating assignments to teachers.

> "The curriculum does not have enough scope for natural sciences, but has too much scope for some other subjects. Really we need more of this kind of knowledge, and we need more in that field, and skills as well, than we so far have time to offer, so in principle I support [the project]. Whether it is as a club or as a compulsory part of the curriculum, whichever way the school presents it, in any event, children need more education in that topic."

The Parent. Puts emphasis on practical matters, but does not understand 'the language of education'. Indicates that discussions about a teaching plan are somewhat unnecessary. Worries about the students' reaction to the Science Club and their motivation to participate. Disengages from the co-design process when the Science Club is no longer closely linked with the school he represents.

This example from the interactions demonstrates the "language barrier" between the educators and the concerned parent - his concerns are not fully understood nor reflected.

> "[T]he topics are very good on the one hand. Everything has been described in detail, but my question is here, how do I sell this to a 7th-grader? There's too much of this info, it's too much for me, too, not to mention 7th grade kids." (Parent)
>
> […]
>
> "And in principle the idea to sell to the kids is simply that this is a club about natural sciences and that science is cool." (EDC educator)

The positions of the different stakeholder groups did not essentially change throughout the co-design process. This can be attributed to at least two factors. Firstly, the EDC team as a facilitator of the process had little previous experience in co-design in this capacity. Secondly, the pandemic and accompanying restrictions played a role as well. EDC educators and researchers noted in interviews

and reflection meetings that they were ill equipped to deal with the restrictions imposed, felt out-of-touch with the network and expressed a general feeling of disappointment and anxiety.

Conceptual model(s)

The concept of co-designing locally relevant teaching is very broad. The case of the Estonian network is unusual in a sense that it did not put schools in the centre of its interventions, rather tried to add on to the formal education system. An opportunity for co-design might present itself, when a school decides to change its approach to teaching, while still adhering to the national curriculum, for instance, when deciding to forego concrete subjects (mathematics, physics, natural sciences, chemistry etc) and opt for project-based learning instead. There have been cases like that in the Estonian education system, but the extent of out-of-school partners involved in the process is relatively unknown. Some schools have involved the parents in the process, and in some cases the decision to teach project-based has been overturned in a matter or a few years[5]. The EDC team did not know of a school about to transform its curriculum at the outset of the SEAS project, and considered the chances of finding an interested school in the given timeframe low.
On the other hand, the idea of a co-designed educational programme led by a non-formal education partner seemed intriguing (we have too little information on whether it was indeed 'transformative') to the stakeholders. Cross-sectorial and interdisciplinary collaboration, however, need to be supported and facilitated carefully in order for the group to form a coherent and shared vision. The present case generally suffered from low buy-in. Stakeholders were interested, but lacked resources (time and attention), and the facilitators did not manage to give enough opportunities to foster a deeper level of cooperation.

Updating and differentiating SEAS concepts, tools, and methods

As discussed above, the concept of co-designing locally relevant teaching is very broad. The co-design needs a lot of 'translation' between stakeholders from formal education and out-of-school context to reach a point of shared vision and understanding. A set of practical tools for facilitators (e.g the scenario method described by Dale et al, 2006) to choose from when preparing for the process would prove most helpful for the future.

The notion of putting the school in the center - not really formed as a concept in SEAS, rather as a principle - might benefit from a slight change. Instead of 'putting' schools in the center, open schooling initiatives might 'help schools take the center(stage)'. Without understanding the needs of the school, there can be very little progress with any open schooling initiative. The willingness to involve out-of-school partners has to come within the schools themselves. In practice, schools might have very little time to dwell on developmental projects. Non-formal education partners like EDC will have the opportunity to regularly offer collaboration projects to schools in an open call format.

Tools: cChallenge and LORET

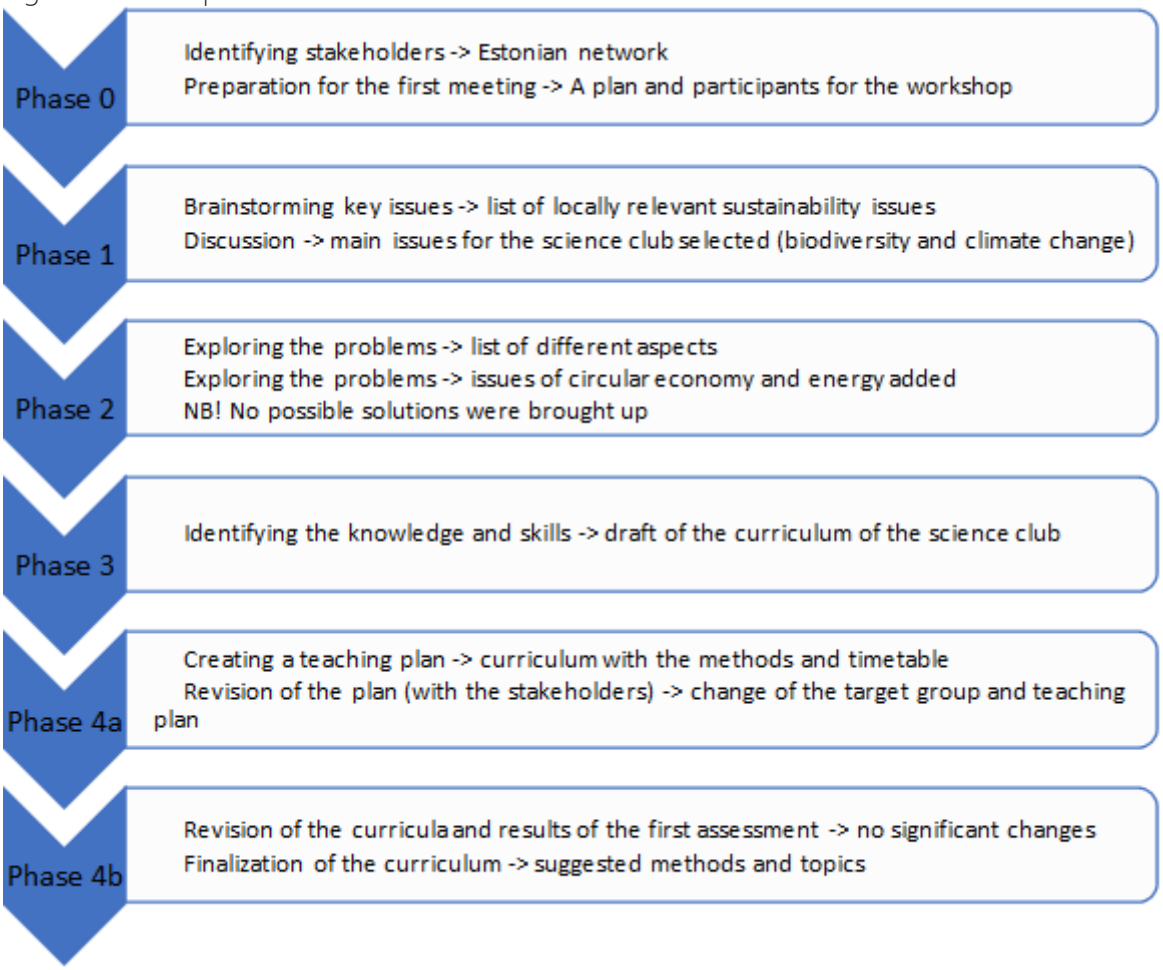
The initial plan for ChangeLabs included cChallenge as means to keep the stakeholders involved and motivated throughout the process. Unfortunately, this did not play out as intended.

As ChangeLabs moved online and the EDC team felt a sense of lost connection with the stakeholders, they made the decision to present cChallenge only to the Science Club students.

LORET served as a good guide for the co-design process (see Figure 1). As the teaching plan had to cover the whole school year, some of the cycles were iterated several times before moving on to the next phase. The LORET Phase 1 was conducted during the first stakeholders' meeting (ChangeLab 1) to define key issues. Phases 2 and 3 were conducted mainly by EDC educators according to the info obtained from Phase 1. The educators explored the problems, reflected on the possible solutions and challenges for each of the thematic blocks (see more below). From there the educators derived the knowledge and skills necessary. Phase 3 ended with a preliminary teaching plan. Phase 4 consisted of discussing the teaching plan with the stakeholders (ChangeLab 2) and concluded with a finalized teaching plan.

Page Break

Figure 1: LORET phases in the Estonian network



EDC educators have pointed out the contradictions in the LORET plan phase 2 – the sustainability issues that are explored are usually "wicked problems" (e.g. Carley & Christie, 2000), i.e. the problems "may not be solvable in any final and definitive manner," (Peters, 2017, p 386) or "are inherently

resistant to a clear definition and an agreed solution" (Alford & Head, 2015, p 714). Especially profound examples of wicked problems are: climate change (e.g. Peters, 2017), energy (e.g. Turnpenny, 2009), and biodiversity (e.g. Redford et al, 2013). Thus, the identification of the skills and knowledge for overcoming these issues was based more on the related challenges and goals than on possible, well-formulated solutions. This is also in better accordance with phase 2 of the LORET plan, described by Östman et al (2019). Those three topics were also the main part of the topics featured in the Science Club.
On the other hand, without considering possible solutions at all, it would be difficult to let the students experience the ability of the access and change of the problems (Van Poeck & Östman, 2020). Therefore, during the science club, the possibilities for the students to present ideas or solutions for different environmental issues by themselves were offered with assignments designed to promote individual inquiry.

Identifying Dilemmas

Here are some of the dilemmas drawn from the analysis of the co-design process, presented from the viewpoints of different stakeholders..

From the teachers' viewpoint there were indications of a tension between following the curriculum versus opportunities (mostly: time) to address socio-scientific issues (SSIs) comprehensively and without rushing through the lesson. The co-design process raised the issue of responsibility to deliver on the curriculum. The fact that teachers were willing to delegate some compulsory topics to the non-formal education partner, might mean they view some parts of the curriculum as cumbersome, difficult, or too time consuming.

As it transpired, both schools involved in the process were highly active in many different developmental projects. Taking part in such projects can be seen as a value in itself to promote the schools' image, and there are indications in the Estonian education system that such schools might reap awards for that (Eisenschmidt et al., 2021). Aside from that, schools that are highly involved in many different projects might have the dilemma of choosing between the amount of projects versus the meaningfulness of their participation and the benefits gained.

From the parents' perspective, the question of what the education provider has to offer to my children might be counterbalanced with what the parents themselves could offer to the education provider (school). Indications of almost a form of clientelism could be noted in the co-design process. On a more general level, the concept of open schooling is more about open cooperation rather than a client-service provider relationship.

The issue of the students' workload was raised repeatedly throughout the co-design process, especially because of the pandemic. The dilemma then becomes: on the one hand, a multifaceted and comprehensive education is generally preferred, and in order to learn about everything, daily schedules are long. On the other hand, how do we lessen our students' workload (which has increased with COVID-19 restrictions) without sacrificing the pursuit of perfect education? Balancing the students' workload did gain more attention with distance learning as a new normality, but the

ramifications of the new normality are yet unclear. One of the school teachers involved in the local network confessed that she faced unforeseen apathy when inviting students to the Science Club :

> "I could do a headstand, talk really well or even better… But this year's 7th graders are so apathetic, and aren't interested at all. I would have never believed it myself that youngsters lack interest. The main excuse: it's the only workout free day, have a workout or music lessons, not interested in the topic etc."

Reporting area 2, Estonia: Challenges and opportunities to transformational engagement, scientific literacies, and motivation

We based our assessment on the activities done within the scope of The Science Club (table 2). Two cohorts of students attended the club in parallel lessons every Tuesday or Wednesday for the school year 2020/2021. The lesson plan was divided into four thematic blocks, one of them (Biodiversity) was resumed in spring to add some planned field trips. The lesson plan was assembled from both new activities, introduced especially for the club (including cChallenge), and activities/methods used in EDC educational programmes.

Table 2: Overview of the topics covered and methods used in the Science Club.

DATE (dd.mm.yy)	THEMATIC BLOCK	TOPIC	METHODS, ACTIVITIES	IN PERSON / DISTANCE
06.10.2020 07.10.2020	Biodiversity	Introduction	Overview (lecture), icebreakers	in person
13.10.2020 14.10.2020	Biodiversity	Nature in the city	A guided tour in park with a guide from the Estonian Natural History Museum	in person
27.10.2020 28.10.2020	Biodiversity	Nature in the city and humans as part of nature	Watching a video, writing a mind map (collectively)	in person
03.11.2020 4.11.2020	Biodiversity	Humans as part of nature	Storyline method[6]	in person
10.11.2020 11.11.2020	Biodiversity	Food chain	Venn diagram, constructing a food chain, EDC's digital educational game "Keskkonnataju" ("Sense of Environment")	in person
17.11.2020 18.11.2020	Circular economy	Food energy	Calculus assignments, worksheets to fill out with the help of EDC hands-on exhibits; drawing and analysing your food plate.	in person
24.11.2020 25.11.2020	Circular economy	Likeliness of life on other planets, geoengineering	Analysis of news articles with the help of a questionnaire, board game	in person

01.12.2020 2.12.2020	Circular economy, Biodiversity	Life and waste in the oceans	Educational programme provided by the Natural History Museum, work in groups	in person
08.12.2020 09.12.2020	Circular economy	"concealed" waste	Discussion, 2 worksheets, demolition workshop	in person
12.01.2021 13.01.2021	Circular economy	Waste from transport	Cooking a meal at home, analysing CO2 emissions caused by the transport of ingredients	distance (Zoom)
19.01.2021 20.01.2021	Circular economy	Circular economy	cleaning out a drawer at home, recycling the unwanted contents	distance (Zoom)
26.01.2021 27.01.2021	Circular economy	(Poster) exhibition	Brainstorming	distance (Zoom)
02.02.2021 03.02.2021	Circular economy	Circular economy	Discussion, watching a film, followed by a quiz	in person
09.02.2021 10.02.2021	Energy	Humans and energy	Tasks at the EDC exhibition + discussion, game "Ampser"	in person
16.02.2021 17.02.2021	Energy	Humans and energy: how do we get electricity at home	Memory game, electric circuit workshop, EDC electricity demonstrations	in person
09.03.2021 10.03.2021	Energy	Electricity in nature	Film "Lightning strikes", Quizizz	distance (Zoom)
16.03.2021 17.03.2021	Energy	Electricity use at home	"Electrician" worksheet	distance (Zoom)
23.03.2021 24.03.2021	Climate change	Climate change, introduction to cChallenge	Alias, video about climate change, cChallenge (in Estonian: Ilmamuutja)	distance (Zoom)
30.03.2021 31.03.2021	Climate change	cChallnege start	cChallenge start, planetarium film program "The Sun - our living star"	distance (Zoom)
06.04.2021 07.04.2021	Climate change	cChallenge	Discussions, writing a blog post	distance (Zoom)
13.04.2021 14.04.2021	Climate change	cChallenge, climate change.	cChallenge discussions and questions, group work and discussions based on the Estonian climate 2100 scenarios[7]	distance (Zoom)
27.04.2021 28.04.2021	Climate change	cChallenge	Discussions, reflection, writing a blog post	distance (Zoom)
04.05.2021 05.05.2021	Climate change	A summary of cChallenge; introduction to waste management in Estonia; brainstorming	Assignments via the Nearpod application (video, post-it, quiz)	distance (Zoom)

		ideas for a virtual exhibition		
11.05.2021 12.05.2021	Climate change	Climate change: where do I feel the best?	Measuring assignments (temperature, noise, humidity etc) outdoors	in person
18.05.2021 19.05.2021	Biodiversity	The ecosystem: everything is connected	Day trip to Aegna island	in person
25.05.2021 26.05.2021	Biodiversity	The ecosystem of a city	Visit to a community garden, orienteering game	in person

Special attention was given to supporting the well-being of the students to achieve intrinsic motivation or integrated regulation of the students as the basis for the pro-environmental behaviour (Darner, 2010). Also, learning in informal or non-formal environments is guided by learner choice (Kisiel & Anderson, 2010), so museums (and science centres) must rely almost exclusively on intrinsic motivation (Csikszentmihalyi & Hermanson, 1995). This was especially apparent after the 2nd Change Lab meeting, when the need of attracting new students to the Science Club (and supporting their well-being) came up (see 1.2). So, during the creation and revision of the teaching plan, and throughout implementing it some of the strategies to support basic psychological needs (autonomy, relatedness, competence) suggested by J. Brophy et al (2014) were used: discussions, teamwork, direct teacher-student communication and feedback, situative learning in authentic environments and gamification to achieve playful learning.

Methods

Data sources and Participants

Data concerning the transformational learning during the Science Club was collected from the three main target groups: the students of the Science Clubs, their parents, and EDC educators (Table 3).

The aim was to assemble the Science Club from two cohorts from 7th graders from the partner schools of the local network. However, the Covid-19 situation in autumn 2020 restricted us from doing so (see pp 31). Thus, the students from other schools in Tallinn were invited as well and students from 10 different schools started participating in 2 parallel Science Clubs in EDC from October 2020 until May 2021 (n_{total}=22; 14 boys and 8 girls; 7th and 8th graders – aged between 12 and 14 years, on average 13.6 years in the beginning of the club; n_{total}=8; 5 boys and 3 girls; 7th and 8th graders – aged between 13 and 15 years, on average 13.9 years at the end of the club).

Qualitative data about students' responsiveness to different sustainability issues and methods/tools used during the science club was collected using group interviews. Two cohorts of students (from parallel Science Clubs) were interviewed after every thematic block (n=4). Audio-recordings and transcriptions of group interviews were used for data analysis. Projective methods (illustrated cards) were included as part of the LA interviews during I and II LA sessions in order add a playful element to the interviews and thus increase the involvement of the students (Catterall & Ibbotson,

2000), as the interviewing was conducted repeatedly after every thematic block (i.e., four times + post-GA). III and IV interviews were conducted via Zoom (during distance learning sessions).

For quantitative assessment, the information from the Global Assessment Instrument (GAI) was used. The pre-test was conducted during the first classes of both clubs (on 06.10.20 n=7 and 07.10.20 n=15; n_{total}=22). The post-test was conducted in May 2021. Also, the testing of the control group (7^{th} graders of two schools from Tallinn, n=22 and n=33) was conducted in December 2020.

In addition, the data was collected from the parents of the Science Club students (n=5) via telephone interviews conducted by the educator of EDC, and from the educators of EDC during the Zoom interviews.

Table 3. Data collected from the Science Club activities.

DATE	WHAT	WHO	DURATION	DATA
6. – 7.10.20	GA pre-test	Students of the Science Club (n=22)		GA report
27. - 28.10.20	I Local Assessment (Biodiversity)	Students of the Science Club (n=6+11)	30 + 30 min	Audio-recordings and transcripts, report
4.- 21.12.20	GA control test	Students of two partner schools (n=22+33)		GA report
2. -3.02.21	II Local Assessment (Circular Economy)	Students of the Science Club (n=4+7)	20 + 20 min	Audio-recordings and transcripts, report
16. -17.03.21	III Local Assessment (Energy)	Students of the Science Club (n=3+6)	10 + 15 min	Zoom recordings and transcripts, report
4. -5.05.21	IV Local Assessment (Climate Change)	Students of the Science Club (n=3+5)	15 + 15 min	Zoom recordings and transcripts, report
25.-26.05.21	GA post-test	Students of the Science Club (n=8)		GA report

14.06.2021 – 30.06.2021	Semi-structured interviews via telephone	Parents (n=5)	30 min each	Field notes
29.06.2021	Semi-structured interviews via Zoom	EDC educators (n=2)	40 min each	Zoom recordings and transcripts, report

Analytical procedure and approach

The analysis focused on three objectives:

1. understanding the students' **motivation and wellbeing**;
2. reflecting on the activities conducted during the club meetings on the topic, with an emphasis on the preferred **methodology** for learning;
3. determining the **key capacities** of **transformational learning** after completion of each thematic block.

Structured interviews for longitudinal study were used after every thematic block (4 times during the school year 2020/2021). Assessment of students' responses to different topics and tools was conducted throughout the educational programme of the Science Club, including SEAS tool cChallenge (during the Climate Change block in March – April 2021). Additionally, semistructured telephone or Zoom interviews were conducted with 5 representatives of the parents and 2 EDC educators.

Audio-recordings of the students' group interviews and EDC educators' interviews were transcribed using an automatic transcription system for Estonian speech (Alumäe et al, 2019). Qualitative content analysis (Hsieh & Cannon, 2005) was conducted using QCAmap.org software.

The categories of the qualitative content analysis are based on the identification of the basic psychological needs, which, according to self-determination theory (Ryan & Deci, 2000) are the basis of motivation and well-being. The **support of autonomy** was detected if students expressed a feeling a sense of volition and endorsement in their behaviour or it was noticed by their parents or teachers; **support of relatedness** referred with students' positive authentical associations with the Science Club, fellow students and the addressed sustainability issues; **competence** was associated with the expressions of effective interactions in this specific learning environment and opportunities for developing or expressing their capacities (Tian et al, 2014). In addition, these categories were supported by quotes from parents' and educators' interviews.

Inductive category formation was used to find the frases mentioning different **methods or tools** for the Science Club to apprehend the common approach of EDC educators and the parents. From students' interviews direct mentioning of different methods was marked up. Special attention was paid to cChallenge as one of the SEAS project original tools. The evidence was searched for

to reveal the SEAS key capacities for transformational learning – critical thinking, reflexivity, empathy and agency, as described in Deliverable 2.2 "Definitions of shared pool of concepts".

Assessing scientific literacy in this specific context was concentrating mainly on the findings of a) the use of scientific concepts engaged with addressed sustainability issues, b) understanding of the processes connected to the phenomenon, c) creative utilisation of scientific knowledge and skills in Science Club context, d) problem solving and e) making responsible socio-scientific decisions (Holbrook & Rannikmäe, 2009).

Theoretical background and methodology of the Global Assessment is described in Deliverable 5.1. For Estonian network constructs 4, 7 and 9 (engagement with science topics and career, motivation, scientific knowledge and pro-environmental behavior) were analyzed in the aim to compare the results of some components of interest/motivation and scientific literacy of the Science Club students in the beginning of the club to the control group and also the change of these components after the completion of the Science Club. Data was analysed with PSPP data management and analysis software. Reliability of variables of pre-test and schools varied from excellent (engagement with science topics, Cronbach alpha 0,91) to acceptable (pro-environmental behaviour, α=0,7). Reliability of variables of pre- and post test was questionable (α=0,64…0,69), probably due the small sample size. Independent Samples t-test or Mann-Whitney U-test was used to compare results of different groups (girls vs boys; pre-test vs schools; pre-test vs post-test). In addition, the open questions about childrens' dream jobs and explaining the concept of sustainability were analysed.

Findings

Interest and motivation of Science Club students

As the students of the Science Club participated in the program voluntarily, their intrinsic motivation and interest towards the club and science/environmental topics in general should have been higher than on average. The results of GA confirmed that: the students of the Science Club were more interested in science topics and careers than the control group of two schools, also their perceived awareness of environmental issues was higher. The pro-environmental behaviour was higher as well, but the difference was not statistically relevant.

The interest in science and science-related career expectations of young adolescents predicts the actual career in science (Tai, Qi Liu, Maltese, Fan, 2006). Estonian studies of popularisation on STEM have brought up the importance of popularizing activities already at an early age and our target group is exactly at the critical age, where the interventions still have impact (Kivistik et al, 2019). Unfortunately keeping up the interest of the students at the age of 13…16 is challenging and it could be one of the reasons why there is a deficiency of long-term popularizing activities for the basic school stage III students in Estonia (ibid., pp 44).

Estonian surveys of formal and non-formal science educators indicate that there are less out-of-school activities for less motivated children, children with special needs, Russian-speaking students and girls (ibid, pp 49 and pp 51). On the other hand, Estonian schools consider

supporting the top-performing students one of the most important goals of non-formal STEM activities (ibid, pp 52), which is also important as according to PISA tests there is constant need of support for the top-performing students in Estonia. We had no data about our Science Club students' performance at school, but both GA results and EDC educators' observations affirmed their deeper interest and knowledge in science.

> "*This wasn't a regular class, was it. I tried to adapt to them, because I haven't had such a big group before, where all know-it-alls and nerds were together. /.../ They really were individuals. /.../ Perhaps during their ordinary lessons they do not have a need to [participate actively] because the answers of the classmates can be silly and there is no need for them to try to think further. Because the ordinary level is too low and boring to them...*". (EDC educator in an interview)

Interest and intrinsic motivation of the students to participate in Science Club activities was also brought up by parents. Only one parent noted during the interview that the initiative came from her at first. Three parents also mentioned the environmental activity of their offspring. It is worth noting that interviews were conducted with the parents whose children took part of the Science Club until the end in May 2021. From the 22 students only 8 finished the intervention, despite the support of the students' motivation and well-being through the program.

Comparing the results of GA in pre- and post-tests we found a slight increase in all constructs, but without statistically relevant differences. For EDC, more emphasis on following statements was especially notional:

- I felt interested in topics related to science.
- I notice scientific facts and events.
- I seek out opportunities to apply my knowledge of science in my everyday life.
- In the future, I can imagine becoming a scientist.

Still, there were some statements that students agreed with (surprisingly) less than in the beginning of the Science Club:

- I tried to connect my own experiences with what I previously learned about topics related to science.
- Scientific topics are practical for me.

However, we cannot conclude that participating in the Science Club changed the interest of our students towards the science and/or environmental issues and career, especially due the small sample size at the end of the program.

Three basic psychological needs as the base of well-being

According to self-determination theory, the satisfaction of the basic psychological needs – autonomy, relatedness and competence – leads to strengthened self-motivation, well-being, and even better mental health (Ryan & Deci, 2000). Even though the support of the students' intrinsic motivation and well-being was one of the aims during the Science Club, the importance of it was enhanced even more due to the pandemic and distant learning. The study about distant learning in

Estonian basic and upper secondary schools during 2020 brought out that 27% of students felt that their learning process was less effective, 44% had to spend more time on learning activities and 40% had some kind of learning difficulties and felt overwhelmed (Tammets et al, 2021). Also, 4 of 5 parents of the Science Club students brought up that school lessons and homework took more time and were less effective during the distant learning period. In addition, parents were worried about the exponentially grown screen time and felt that Science Club's online lessons were less interesting and less beneficial. EDC educators also referred to the problem with students feeling overwhelmed as one possible reason for quitting the club.

However, during the group interviews of the Science Club students these problems were not mentioned. Children expressed their thoughts and feelings, named interesting and helpful topics and methods. Mostly, the opportunities to endorse one's competences were brought up. Feeling of mastery was expressed: *"I understood things in every lesson!"; "...(topics) were interesting for me, but I understood them well. Actually it is not interesting at all when you do not understand (things),"*.

The possibility to learn something important (and interesting) for themselves was described quite often: *"And we learn different things about natural sciences. It is interesting, we can study and learn a lot!"*; a student showing an illustrated card said: *" I picked this card with a lot of keys in the picture, as the keys symbolize the answers and so far I have known all the answers to all the questions. I am eager to learn more,"*. Also, specific knowledge valuable for the future career or the future in general was pointed out (again, while showing an illustrated card): *"Here's a scientist on the card. Science is something I would like to do in the future as my job and right here and now I am trying to gain knowledge to become a scientist"; "And what we learn here could and will help (the environment). If I know something then I can pass this knowledge on and on and on,"*.

One EDC educator mentioned that children felt less competent during the group assignments (especially in the beginning of the club) and writing the blog. The other EDC educator reflected that students seemed to feel competent during the design of the digital exhibition about waste management – the topic had a personal meaning for them, also there was a lot of information in the media due to the so-called garbage scandal in Estonia at the time.

Relatedness as the feeling of being socially connected and cared for by others was not directly mentioned by students, but they expressed general well-being and importance of other group members: *"I picked this card because there is a squirrel who is not feeling bad, I have the same feeling,"; "In our group, there are some people who know more about one subject and others who know more about another subject,"*. The non-verbal communication of the groups also supported this conclusion – the students were determined, answered the questions without any anxiety and there were no critical notes or acts towards each other.

Especially parents emphasized the positive relations between their child and the club, and a good connection with the EDC educators was mentioned. One EDC educator noticed that students expressed a sense of belonging to the science club and a connection with the educators, and they cooperated well during the program, especially after lockdown: "*They said at the end [of the club] we'd sat all this time at home and had to do things on our own that it is such a joy to do something together*". However, no expression of friendship or even personal connections out of Science Club could be recognised. Instead the growth of joint activities with the families were mentioned by the parents, especially due to the cChallenge, but not only. "*He was interested, he reflected and discussed with us a lot. And he came up with the interesting questions that we tried to find answers for together*," one parent remarked in an interview.

Expression of autonomy, the need to self-regulate one's actions and experiences was not so prominent. Mostly it was mentioned in the way "I was able to do/think it by myself". EDC educator A also brought up that students had a lot of self-awareness, they discussed and even argued with others and enjoyed the learning process.

Gender issues

The main target groups of the programmes of EDC are school groups and during the planning period of the Science Club the idea was also to conduct the program with two school classes which were already completed. So the gender issues have reached only minor attention so far in EDC. In the open science club the representation of boys was more prevalent: 14 boys and 8 girls in the beginning in October, and 5 boys and 3 girls at the end in May. Gender aspect was mentioned also by one of the parents: *"I do not know that there was anything she didn't like. Perhaps only that she was the sole girl in their group."*

Global assessment did not indicate any statistically relevant differences between girls and boys, nor in the interest in science issues and career nor environmental awareness or behaviour. Also, describing their dream job the answers of girls and boys didn't differ appreciably, e.g. both mentioned professions of engineer and scientist. This is in compliance with general statistics, that girls mostly do not choose STEM-related careers, even though there is no significant difference in performance in STEM subjects in school. There is not enough data about gender representation of non-formal education, including science clubs, but during the survey in 2017 there were no girls-dominated STEM-related extracurricular activities (clubs) (Kukk, Lamesoo & Papp, 2017).

Tools and methods

The Estonian Lifelong Learning Strategy 2020 introduced the new, constructivist concept of learning, where one of the most important goals was the change towards collaborative learning. The transformation in social processes accompanying the learning process should take place, and the shift from individual operating model towards more cooperative and collaborative relations on student-student, student-teacher, teacher-teacher and teacher-school leader level should emerge. The principles of constructivist learning have been important to non-formal education institutions for longer period, e.g. DeWitt and Osbourne introduced the Framework of Museum Practice (2007) encouraging *joint productive activity* - which involves pupils working with each other and with the teacher, supporting discussions, cognitive engagement and literacy/research skills. For EDC educators the question about the ratio of individual versus cooperative methods was raised during the designing process of the Science Club, so one of the main issues explored during the students' interviews was their opinion on the used methods and tools.

35% of used methods during the Science Club were individual and 65% cooperative (or collaborative). Statistics of students' interviews indicated that children mentioned different methods all together 152 times and 36% of mentioned methods were individual, so there were no preferences in general. Still, the share of cooperative methods increased after the lockdown. As mentioned earlier, children said to an EDC educator that they felt the joy of working together after being alone at home. Also, the use of cooperative methods by schoolteachers during distance learning decreased considerably and the learning process based mainly on individual tasks (Tammets et al., 2021) made teamwork in Science Club even more valuable. Besides that, students brought up that they had more motivation during the groupworks, they could get to know each other and could compare their own thoughts with others'.

Some of the methods we classified as individual, ended up more cooperative or even collaborative. Especially during distance learning, when the online-lessons were shorter and students had several home assignments, the parents and siblings were also engaged. Supremely, parents brought up that they took part in the cChallenge. As one parent remarked: *"We did cChallenge together and I also influenced the ideas, what to do, and then we did it together,"* Another parent added: *"We did cChallenge together. The whole family was involved [the challenge was living on a vegetarian diet]. We helped her and it was cool!"*

Parents were also more informed about the field trips, which were one of the favoured methods children mentioned during the interviews. Students were asked to name the methods they preferred in different thematic blocks and give their reasoning as well. The most valued activities were:

· Activities that gave them the possibility to do something by themselves (e.g. electric circuits workshop, measuring assignments, cChallenge, the storyline method). This feature combines real, authentic experiences (often also hands-on activities) on one hand and autonomy on other – possibilities not only to act but to discuss openly, make meaningful choices and mistakes along the way as well.

· Videos and movies, sometimes combined with different tasks or discussions. This was quite a surprise to the EDC team, but probably children are used to relying on visual information and it was a safe and not overly demanding activity for them.

· Combined methods, where different activities supplemented each other. Students' conclusions were intelligent and reflected their understanding of learning strategies: *"I think that this kind of combination is the best. Because different activities give you the things you can't achieve with others and so you can get everything at the end,"; "I think that there is no such one method you should use all the time, but one must use different (methods) and these all are good in their own way. And you learn the same topic in different ways,"; "I'm sure that we learn very well, when we are truly present"*.

EDC educators noted that their intention was to add more active, playful activities to keep up students' interest and wellbeing, especially during distance learning. They added that many of the planned methods were not applicable during the lockdown and had to be replaced. The immediate relation between educator and students helped to use appropriate activities. Evenmore - the good relations between educators and parents were taken into the consideration: *"It would be especially good, if it (home assignment) would make the parents happy as well, like this task of cleaning out a drawer and..., so it wouldn't be like, ah! the kid is ordered to do something silly, but these activities should have a positive undertone as well."* Also the need of practicing teamwork during different activities was brought up. "*One has to practice teamwork in the aim to really be capable of collaboration, from as early age as possible. /—---/ If we think about the working world, cooperative skills are as important as independent work skills,"* one educator reflected. Also reflecting and discussing was mentioned as a valuable and essential part of the lessons.

cChallenge was brought up on several occasions, as a truly helpful tool during the distance learning, some proposals were made (see 1.3.6) and one EDC educator expressed a great gratitude to the cChallenge team, who provided the technical opportunity in such a short notice and were very supportive.

EDC has earlier conducted some science clubs as well, and some challenges and obstacles were present that needed further investigation. This study of different methods has valuable input for prospective lesson plan development.

Transformational learning

Transformational learning is fundamental for sustainability work because it engages learners in a participatory process of constructing meaning, and helps learners question and reframe unconscious attitudes and values," (Burns, 2015). During the local assessment, the evidence was searched for to reveal the SEAS key capacities for transformational learning – critical thinking, reflexivity, empathy and agency.

Critical thinking – in its wider sense, was found only to a limited extent from students' interviews. Pluralities of perspectives were brought up mainly in contrast "me (the good ones) and the other (not so good ones): "*Yes, this topic is relevant to me because it shouldn't be relevant only to me, but*

it should be important to others, as well. Because we all are here on this planet and if we waste all these things or more wastes will come, our life will be really bad,". However, some interesting observations were made that are remotely related to critical thinking – the students were critical of their current knowledge and had a strong desire to aspire further.

Reflexivity was slightly represented. Mostly the perspective of other citizens was considered (e.g. *"I also think that the biodiversity in the cities is important because there are lots of people living in the cities and nature provides them oxygen and without nature, they simply couldn't stay alive,"*). EDC educator A mentioned that students were open to the opinions of the co-students, they had lively discussions that could be a sign of reflexivity as well.

There were some indications of empathy, mostly towards other species but also to other humans *("I think that this is important, because we all live in the city and we need this for the oxygen and for some animals who could live here"; "I picked this, as plants need to be taken care of even when it rains"*).

Agency was more evident in the interviews, especially both educators and parents described the capacities of transformational learning mainly through the prism of an action. One parent noted: *"She has always been caring, has picked up the garbage of strangers. But now there is an interest in nutrition, probably started from the Science Club." Another parent*: *"She has always been in this environment, because her elder sister is an environmental activist, vegan etc. The younger girl is also quite conscious already. She has always been caring as well. She has sorted wastes all her life. She still eats meat, though."*

cChallenge was brought up several times, as it affected the parents the most (e.g. parent A: *"..it affected the whole family. Younger brother (4-years old) wants to pick up garbage all the time now,"*). The personal sphere of transformation (O'Brien & Sygna, 2013) of children must include a major share of beliefs, values and worldviews of their parents, also the activities of the students in this case were carried out at home surroundings, so in a way our students were "environmental agents" in their homes. As one EDC educator reflected: *"Maybe it was even better that we could actually give the assignments that should increase agency. If we had done all the things in the EDC individually or with the group /---/ then we would have done more this kind of actions that take place inside of this group and the people outside our club at the homes etc. would been engaged less./---/ So definitely the discussion with the community, even with the small community, was broader."*

Some of the thoughts of the students were truly heart-warming: "*I think it (biodiversity in cities) is very important, it needs to be understood for example when electing a president for example. If the president makes a statement, you just don't have to nod but you need to be able to decide whether this statement is right or wrong. So you wouldn't accidentally elect anyone who will start polluting the city,"; "As the world is not in too good of a place right now in the sense of nature, there should be hope that it will come better somehow. And what we learn here could help it and hopefully will. If I know something then I can pass this knowledge on and on and on and maybe then we could escape from this world to some beautiful meadow*".

Scientific literacy

EDC has a goal to support scientific literacy among schoolchildren and wider audiences as well. However, as a non-formal education institution, EDC has minor exposure to the assessment of scientific literacy. The programs of the EDC are well connected to the national school curriculum and are relying on the level of competences the students should have on certain levels. The programs are usually quite short and if some adjustments are needed on specific cases, then they are made by an EDC educator *in situ*. Preparing the teaching plan for the Science Club the educators also relayed the opportunity to make cooperation with partner schools and teachers to achieve input directly from the school, the plan that didn't revealed. Hopefully GAI will give some general information about the Estonian students among the others. Still, some conclusions can be made based on interviews of the students, parents and EDC educators.

The Estonian curriculum in natural sciences in 7th grade is focusing on the adaptation of several abstract and casually-based concepts. Accordingly, our target group is in the turning point of conceptual learning. Even though the reproductive skills of the students were not so relevant in the context of the SEAS project, we tried to map the use of scientific concepts in the students' interviews. Unfortunately the data did not allow for it. On the one hand the form of focus group interview didn't support this kind of findings, on the other hand, students brought up the concepts in the context of the Science Club, personal relevance or some topical problem. Understanding processes connected to the main themes of the Science Club were presented more often, e.g. *"It is important, we use energy daily and it is even inside of us. We also need energy. Not the electricity, but energy so we could move and work and learn. Also, to use phones and computers and TV, we need energy for all of that!"*.

Both parents and educators mentioned that Science Club broadened general understanding and knowledge of the students. Parent A: "*It broadened his world view. He saw things from different angles, they usually do not do that at school (maybe they lack time).*" An EDC educator monitored the cChallenge blog and noticed the shift towards a broader understanding of environmental issues. Another EDC educator was concerned because distance learning limited the possibilities of common discussions, important to sense-making and broader context, even though they made responsible decisions (during the cChallenge): *"Although they concentrated on their own assignment, they still discovered something for themselves. E.g. one switched off the lights – my God, I leave the light on so often! /---/ They all discovered some small nuance but this was only loosely connected to environmental awareness. I would have taken them together into the classroom and… conducted some games or discussions or… So yes, you do it and now we think about it from this angle, how we… This possibility to bind things together was missing /---/ We should have got the wider picture, to understand what I do, why I do it and why everyone else should also do it*."

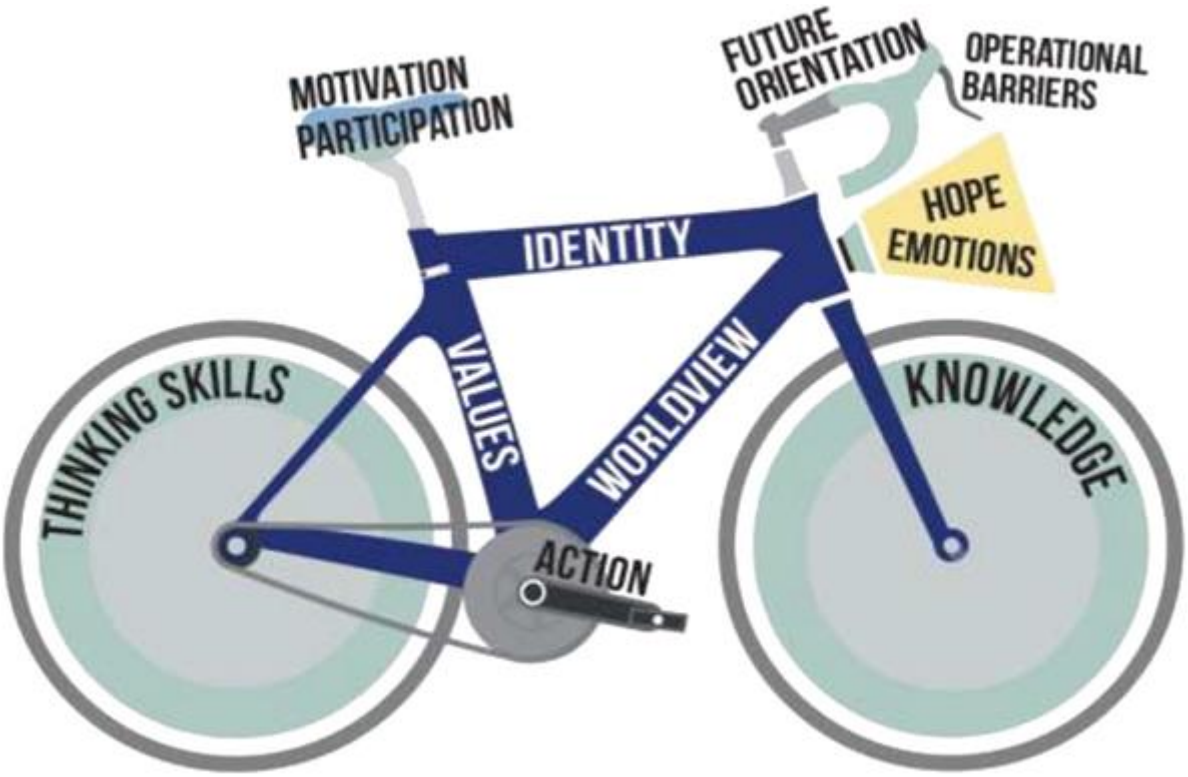
Problem solving skills were not apparent from the interviews but the creative utilisation of the evidence-based scientific knowledge and skills (scientific creativity), particularly with relevance for

everyday life was mentioned by one educator in the context of preparing for the digital exhibition: "We had the assignment to design the virtual exhibition. Or actually collect ideas for that. And this was the activity where they demonstrated their scientific literacy! /---/ These questions they formed were, a kind of... sharp and erudite! This was really cool! /---/ It means that their plan was to make an exhibition about wastes and it seemed to me that they were pretty familiar with the topic, they had worked through the material and they had reasonable questions." Students collected information from different media and demonstrated abilities to reflectively and productively engage it to the new form of knowledge.

1. Implication to updating and differentiating SEAS concepts, tools, and methods

The SEAS project brings together valuable and diverse competence of project partners. It is evident also in the framework of key concepts of the project, providing the common conceptual basis to all the partners. However, EDC as one of the non-academic partners has somehow struggled with comprehending the relations and hierarchy of the general concepts of open schooling. Visual facilitation could make this framework more comprehensive, especially during the dissemination of the results. One good example could be a bicycle model on climate change education, created by Sakari Tolppanen and his colleagues in Finland (2017). The metaphor is easy to remember and the objectives and special features are "knitted together" in a visual and coherent way (figure 2).

Figure 2: The bicycle model on climate change.



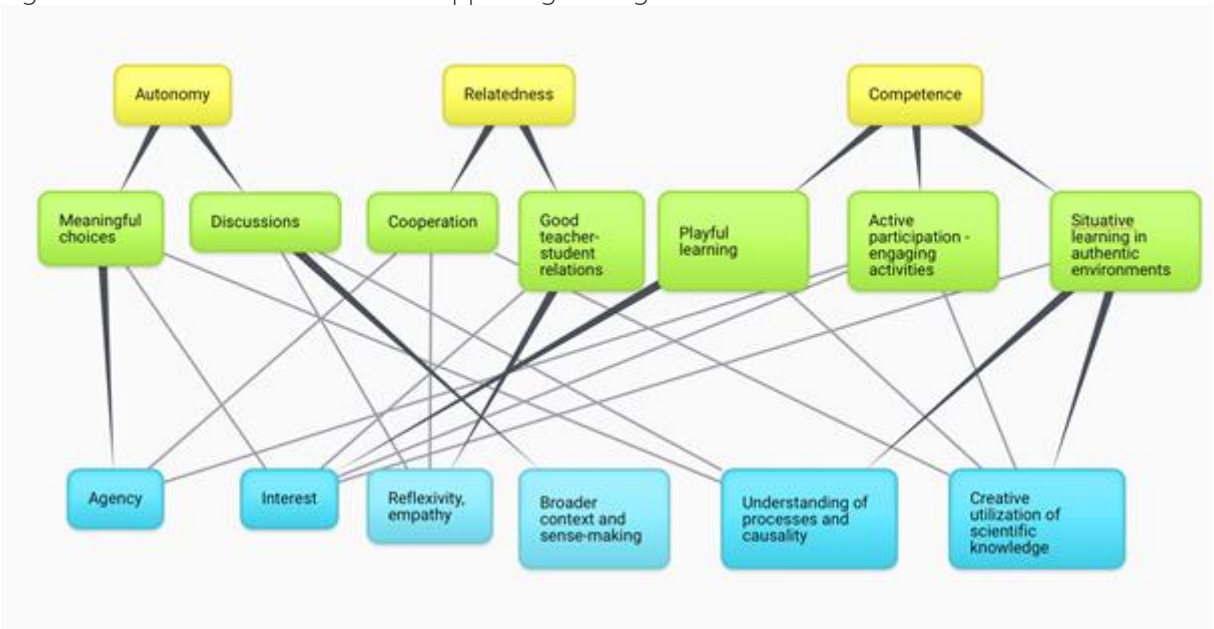
Further findings indicate that the model could be useful also in sustainability education in a broader way (Cantell et al, 2019). Also, the EDC team found that some of the concepts of the SEAS project could be "translated" to the parts of the bicycle. For example, the wheels – thinking skills and knowledge – could be also defined as scientific literacy. Saddle should be comfortable to sit on, thus expressing motivation to participate and is supported by basic psychological needs (incl wellbeing) etc.

4. Synthesis of findings

1. Conceptual model(s)

The analysis of transformational engagement, scientific literacy, and motivation in the Science Club was based on self-determination theory - the concept of three basic psychological needs and the strategies to support them. As the motivation and well-being of the students was considered to be the basis for the pro-environmental behaviour and learning in a non-formal environment, some of the approaches used by EDC educators to support the autonomy, relatedness and competence of the students are described on Figure 3. Our analysis pointed out connections (some of them more obvious, other less) between these strategies and some features of SEAS conceptual framework. From transformational learning capacities, agency seemed to be facilitated by cooperative learning, engaging activities (e.g. cChallenge) and meaningful choices endorsed by educators and/or parents. Reflexivity and empathy were less noticeable, and more teacher-students discussions could have improved that. Additionally, discussions were brought up many times by the educators as facilitators for different aspects of scientific literacy. Good teacher-students relationships with engaging activities and playfulness should keep up the interest of the students. In general, many of the strategies used in Science Club for supporting the wellbeing and learning of the students could be a considerable foundation for further program design.

Figure 3: Effects of the motivation-supporting strategies of the Science Club.



2. Identifying Dilemmas

One of the most important dilemmas for EDC as the non-formal education partner was the question of target groups. Are extracurricular science education programmes most valuable to students already interested in the field, or those who would need further instructions than received at

school? Who would benefit most: the top-performers or the underachievers? The Estonian education system, on the whole, has generally focused more on helping low achieving students perform better. The most recent PISA test results show that the percentage of low performing students has decreased (and has been lower than the OECD average to begin with), but the percentage of top performing students has increased respectively[8]. Even though both approaches are equally important from the viewpoint of an equitable society, there remains an issue with the amount of resources available. From the viewpoint of a non-formal education partner, it is certainly easier to motivate high-performing and interested students rather than low-performing students lacking interest in science.

The second dilemma is to do with gender equality. As noted above, the Science Club had more boys than girls involved, which is not usually the case with other educational programmes provided by EDC. The entire class usually enroles in an EDC educational programme and classes usually have a similar number of both girls and boys, and therefore gender representation has not usually been an issue. With the open call, the number of boys interested in the Science Club was higher than the number of girls. This does refer to the general problem of perceiving science as an inherently male field. Also, as noted above, being the only girl in a group of boys did seem an unwanted outcome for the female student.

On the other hand, 84% of 7-9 grade teachers in Estonia are female. 54% of Estonian teachers are older than 50, whereas the OECD average is 34%[9]. The EDC educational staff at the time of the Science Club included 5 women and 2 men. The dilemma that presents itself is: how to bring more female students to science education, while not losing the interest of male students?

Reporting area 3, Estonia: Challenges and opportunities to teaching scientific literacy

Methods

Data sources and Participants

In order to make observations about the teaching process, the EDC educators (n=2) involved with the Science Club were interviewed in June 2021. The interviews were conducted by following a semi-structured questionnaire. Other data sources included in the analysis: the teaching plan, study materials and assignments prepared for students.

Analytical procedure and approach

We were interested in finding out:

- Q1: Which principles did the educators follow when creating the teaching plan for the Science Club and working with the students?
- Q2: Which teaching and learning methods did the educators value the most?

Inductive thematic analysis was used to analyze the interviews. The reappearing themes from the interviews were categorized in terms of the educators' role perception (Q1) and teaching practice (Q2). The findings were interpreted in the framework of different teaching traditions in environmental and sustainability education with regards to each tradition's strengths and shortcomings as described by Öhman and Östman (2019). They label the three teaching traditions as fact-based, normative, and pluralistic. The first relies heavily on factual (reliable) knowledge, while omitting values of all sorts. The second relies on predetermined norms and values, and while the approach

is generally seen as effective at generating personal change, the democratic aspect of education is violated, as it were. The third is based on the premise that sustainability issues are political and conflicting in nature, and should therefore be dealt with in democratic processes, which can, in turn, be viewed as time consuming and challenging in a school setting.

The educators were later presented with climate change education scenarios based on the three teaching traditions and further developed by Vanderplas & Van Poeck (2021) and asked to choose a reply for each of the three questions that they sympathized most with when preparing for the Science Club and working with the students on the issue of climate change.

The three questions were as follows, each with three accompanying answers corresponding to one of the three teaching traditions outlined above:

- What do you think is the best way to solve the climate problem?
- How do you think about climate education?
- How do you see your role as a teacher?

The teaching plan for the Science Club and assignments given to the students (in the format of written instructions and worksheets) were read to supplement the analysis of the interviews.

Findings

Role perception

Both educators stated repeatedly that they valued the opportunity to give the Science Club students a broad and comprehensive overview of the issues of climate change and sustainability. They stressed the importance of the students understanding "the basics of science" and being able to connect factual knowledge into a "wider picture".

> "What often is lacking in school is putting the piece of knowledge or topic into a comprehensive general picture. Here we didn't have all that either, because we didn't have the children or weren't able to do everything… Ideally we had it, but it went how it went…" (Educator B in reference to the COVID restrictions)

The educators indicated that their role was to give the students a higher level of understanding of how sustainability issues are interlinked. Zooming in on one issue seemed somewhat 'dangerous' in that framework - educators used the word 'danger' repeatedly - as it might have meant the loss of a general, comprehensive understanding of the issues.

> "I don't think Energy Discovery Centre should build a Science Club on [the issue of the declining number of] bugs… Focusing solely on that topic means that we will not develop that comprehensive understanding of how all the different things in this process - I don't know, the extinction of bugs - lead us to even worse circumstances, what aspects and factors interact there for something to happen or not to happen…" (Educator A)

When presented with the teaching traditions' scenarios, both chose the answer based on the normative tradition as a favorable answer to the questions concerning their role as a teacher: "As a teacher, I find it important to teach students appropriate knowledge to understand climate as well as the necessary skills to tackle the climate issue. [etc]" On the other hand, when asked what would be *the best way to solve the climate problem?*, one educator again agreed with the answer correlating with the normative tradition, while the other chose the approach connected to the fact-based teaching tradition.

The educators also attributed importance to making Science Club meetings fun and engaging for the students, and expressed delight when describing their students' positive feedback, gained directly from the students themselves or via their parents.

> "Considering the circumstances we did pretty well because we managed to generate pretty cool assignments, and the kids' feedback was pretty good." (Educator A)
> "[K]ids had told their parents that they had formed a good bond with me. This is a really lovely example of how a kid does want to come [to the Science Club] if he says so to his parent as well." (Educator B)

Educator A worked in the formal school system in parallel at the time of COVID restrictions and described how the insights, tools and tips shared in the teachers' lounge helped to design the extra-curricular Science Club meetings as well, as half of the meetings had to be facilitated online. "But [Educator B] really managed to add gamification elements to it, so it would be more interesting for the kids…" The notion of *gamification* and *making things fun* is in accordance with supporting competence, one of the three psychological basic needs further described in local assessment area 2 (pp 19) to support wellbeing in learning environments (Brophy et al, 2014).

Teaching practice

The range of assignments given to students and methods used was generally quite wide (see table 3 pp 15-16 for an overview). These included individual and collective tasks, tasks that required basic calculus and fill-in-the-gaps, but also discussions and debate (creating mind maps, the storyline method[10]). Interestingly, when asked about which principles climate education should follow (Q2: How do you think about climate education?), one educator chose the answer in referring to the fact-based tradition (When students know the correct facts about climate change, they will automatically act more responsibly), the other quite the opposite - the pluralistic tradition (Education about climate change should have an open outcome rather than pursuing predetermined behaviour or attitudes). Based on the teaching plan, the Science Club had assignments stemming from both traditions - fact-based and pluralistic.

The educators talked about giving students the opportunity to *do something by themselves*, thus fostering *independent inquiry*.

> "What they did themselves at home, that they really praised: I could do it myself, and I got some knowledge out of it or confirmed their knowledge. […] We had reached some type of knowledge and now we were applying that to something and they could discuss and they really did debate things, really! And something came out of it. We didn't just discuss things theoretically… […] They really liked it when they could do something themselves, in a group, discuss, really apply these things they'd learnt. You often don't have time for that in school. (Educator B)"

The interviews indicate that both educators valued cooperation and teamwork as a method in teaching and learning. They reflected that the group of students involved in the Science Club were not, at first, inclined to work together as a group, mostly because they were from different schools and did not know each other. This was reported as a matter of concern by both educators, and they actively worked to facilitate a sense of "us" within the groups to support relatedness (see pp 18 for

more about the students' well-being and motivation). Both educators noted that they perceived the students to be academically more advanced than the average student, but considered them also to be more introverted than the average student. The educators reported using teaching methods and approaches to try to coax the students "out of their shells".

Although signs of democratizing inquiry can be noted, both educators put high value on factual information and constructed tasks for students that relied heavily on factual knowledge and scientific methods (e.g. measuring assignments outside to determine temperature, air humidity, noise etc; answering questions and filling out worksheets after watching a video; calculating power consumption room by room at home etc). Tools and methods such as cChallenge (also the storyline method) were seen as interesting supportive instruments to confirm the knowledge gained. As one educator put it:

> "Yes, we can think about things and philosophize on our own, but at the end of the day if there are too many activities without a supervisor, then what may be missing is the understanding whether you've acquired and confirmed the right or wrong knowledge. That's the thing about natural sciences, that false impressions may easily form, and those have to be corrected early so the foundation won't crack." (Educator A)

To sum up, both educators valued information about climate change and sustainability very highly and perceived their role as an educator to present their students with relevant facts, but also did venture to include activities that would promote a more democratic approach to the issues.

Conceptual model(s)

The three traditions in environmental and sustainability education described by Öhman and Östman (2019) was a useful concept to refer to when making observations about teaching in the context of the Estonian local network. As the authors have noted, the value of describing and categorizing these traditions is not so much in determining whether a teaching practice is intrinsically "right or wrong", but rather in reflecting on when planning lessons and analysing one's teaching practice on the whole.

The third, pluralistic tradition, is in essence, connected with the SEAS concept of democratizing inquiry. As observed above, even teachers who might mostly value a fact-based teaching practice, do acknowledge that there are different perspectives to sustainability challenges and design their practice accordingly. To what extent teachers actually consider sustainability challenges as socio-scientific issues, is difficult to determine within the limits of this assessment.

Updating and differentiating SEAS concepts, tools, and methods

The educators used the cChallenge tool (Ilmamuutja in Estonian) while the Science Club met in Zoom at the time of school closures and restrictions set on extra-curricular activities. As presented in the findings section above, the educators considered the tool to be somewhat limited in its capacity to support scientific literacy. On the other hand, the cChallenge tool did seem to support

the feeling of agency in students (see pp 23 for more), and educators noted in their interviews that the 30-day challenge was a good focal point for their weekly Zoom meetings. As the online meetings were shorter and educators felt less connected with the students, reflecting on each student's experiences with their chosen challenge managed to uphold a sense of relatedness. On a methodological level, though, the educators sensed the need to support the students by providing them with a short list of guiding questions on which to build their reflections and later, their blog posts on the platform. The educators noted that they believed the students were too young to be able to think of the blog posts and reflect on their experience on their own - this, in their view, is a higher level of competence that can be expected from much older students. A weekly reflective group meeting worked generally well.

Identifying Dilemmas

The approach to teaching: **how to balance a fact-based approach with developing one's students' democratic competences?** How much should one spend (valuable!) classroom time on debates and discussions, when the curriculum expects a fast-paced journey through a number of fact-based topics?

The dilemma presented by the unique Covid-19 situation: **how to manage the tension between the expectations set by the curriculum and the fear of losing the emotional connection with students?** The formal education system is something that students are required to take part in. Extracurricular activities, on the other hand, are in danger of losing their unique identity when posed with the command to operate from a distance.

A non-formal education partner shared their insights to this in a ChangeLab meeting: "The end of the last school year (2019/2020) showed us that the parents didn't much support extra-curricular activities that were done online, because all of the compulsory school work was done online, you see… The idea of the (out-of school activities) was lost. There was only the content left, and the parents didn't see the point of making an effort there in addition to everything they had to do anyway." Extra-curricular activities are not mandatory, quite the opposite, students can choose extracurricular activities based on their personal interests and what they enjoy doing. The educators involved with the Science Club confessed that they feared losing contact with the students and tried to make the online meetings as engaging as they saw possible.

They also worried about the students' screen time - children were already spending a whole school day in front of screens, it seemed excessive to the educators to require them to have even more screen time due to an extracurricular activity. The educators' solutions were to give students more home assignments than they would in normal circumstances. Therefore, new tasks were added to the teaching plan: the tasks of cleaning out a drawer and recycling the contents; choosing a recipe, cooking a meal and making notes on where the ingredients were from etc. This move, in turn, helped to involve parents and families in the Science Club activities more than the educators had initially hoped for.

COVID-19 Impacts

The activities within the Estonian network were affected by restrictions set at different times and capacities due to the pandemic. Energy Discovery Centre (EDC) is nationally recognised in the category of museums and visitor centres and was subjected to closure at least three times between March 2020 till March 2021, with the longest closure lasting two and a half months. New restrictions were often imposed by the government with very short notice (e.g three days).

As time progressed, school closures and restrictions on visiting museums and visitor centres were not always applied at the same time. That meant that schools might have been on distance learning for weeks, while museums and visitor centres were open, in other cases, schools were open, but it was generally advised to refrain from visiting any public place apart from schools, workplaces, and grocery stores. As of 2021, schools and municipalities have the right to organize school work as they see fit, based on their evaluations of the epidemic situation within the school. This has meant that the EDC's visitor numbers have dropped significantly and work has had to be organized remotely.

Working in the local network

After the kick-off, work with the stakeholders had to be organized remotely, and almost all meetings were facilitated via Zoom. Initially the EDC team had planned different face-to-face activities for the stakeholders, in order to familiarize them with the concept of a science centre as a non-formal learning environment, and to support the formation of a common vision for the co-design process. As meetings moved into Zoom, the EDC team struggled to keep and nurture a shared vision for the process. Different stakeholders did not, in effect, use a shared language, as it were, in discussions, and were not all invested in the project.

Managing the work within the network solely via digital contact was challenging, especially because the EDC team usually focuses on hands-on activities at the centre. The practicalities of joining Zoom meetings late and leaving Zoom meetings early meant that the meetings were more chaotic and getting feedback from participants more complicated than usual. The EDC team felt that their know-how and experience with stakeholders did not translate well into a purely digital format.

The Science Club was planned to start in September 2021. At the time, schools were operating with the knowledge that lock-downs may happen at any point in time, and schools might close in a case-by-case situation, not all at once. The air of uncertainty led to the decision to send out an open invitation for students to join the Science Club instead of organizing it exclusively with and for the two stakeholder schools.

Learning and teaching science with a focus on sustainability

The Science Club meetings had originally been desig ned to be face-to-face and the teaching plan included many hands-on and in-person activities. As distance learning became the new norm, the EDC educators moved on to online applications, video calls, instant messaging etc to facilitate the Science Club meetings. "The methodology part gave us a headache," remarked one educator. In

2020/2021 one of the EDC educators was working both in school as well in EDC - from that connection we learned that teachers were ready and willing to share the best practices and tools for distance learning, and that quite a few of the methods indeed worked for the Science Club, as well. EDC definitely gained new experiences and a new level of competency with working with students via online applications.

On the other hand, educators noted that they felt the loss of meaningful contact with their students, and remarked in interviews that students would sometimes refrain from switching on their cameras on Zoom. Such a simple thing - not seeing their students' faces - hindered the teaching process considerably.

As the year went on, the number of students involved in the Science Club went down. "With Covid, children's study load changed anyway, and as the social support system vanished as everyone isolated to their homes, the children were lost, too. [...] I don't know the reasons, whether they lost motivation or they felt overwhelmed," one educator offered as an explanation. The reasons why some students gained from distance learning, but others lost, and how to make up for the differences created, will definitely be fodder for future analysis.

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5. Italy local assessment

Reporting area 1, Italy: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface.

Methods

Data sources and Participants

The Italian local network is leaded by University of Bologna (UNIBO) with the collaboration of Fondazione Golinelli (FG), which represented the ground of the network. Researchers and experts in education and teacher training from the two institutions represent the steering committee of the local network which meet up on monthly basis to guide the activity of the network. Among other stakeholders involved in the network, two collaborating partners participated quite actively since the beginning: The Euro-Mediterranean Centre on Climate Change (CMCC) and the Climate-KIC project. There are also several other occasional stakeholders who participate in the network according with special needs. The core of the Italian open schooling network is represented from the schools. According with the SEAS principles, we strongly put the schools at the centre and make them the core of transformational change. The schools constituted the network were:

- Istituto Comprensivo of Meldola (FC) (K-8 curriculum): composed by kindergarten, primary school and lower secondary school
- ITAER Baracca of Forlì (FC): Technical Upper Secondary school which comprises aeronautical curricula
- Liceo Scientifico A. Einstein (Rimini): Upper secondary school with a scientific curriculum
- ITAC Scarabelli-Ghini (Imola): Technical Upper Secondary school which comprises agricultural and chemical curricula.

However, we have left the border of the network quite open, and we have hosted in some moments some schools[27] and teachers who have not the conditions to follow entirely the project but who were still interested in reasoning about projects' idea and build the basis for future actions.

Each school which participates in the network, chose internally the structure of participation. Table 1.1 summaries this kind of information. The common thing that is important to point out is that for

[27] In particular, two schools carried out also one iteration each, they are:
- Liceo Ginnasio Statale M. Mighetti (Bologna): Upper secondary school with a classical curriculum oriented toward humanities subjects
- International Experiential School (Reggio Emilia): Private (lower and upper) secondary school with a classical curriculum oriented toward humanities subjects.

all these schools the involvement of the principal was not only formal but there was also a substantial support.

Table 1.1. Structure of participation of the schools.

School/Context	Teachers	Disciplines involved	Structure of participation
Istituto Comprensivo of Meldola (FC) (K-8 curriculum)	5	Science and Math, Technology, English	The group of teachers is coordinated by the teacher of Science & Math. Within the school they collaborate at the project within all the teachers of the STEM Department with a collaboration of the English teacher. They aim to work at a level of curriculum within the context of STEM civic education (*) for pupils of grade 8. They coordinate the changes started from working transversally with the teacher of technology on a structural reform of grade 8 for the whole school. ***Stakeholders:*** Major of the city, political institutions, families and citizens.
ITAER Baracca of Forlì (FC)	7	Physics, Chemistry, Natural Sciences, Italian Literature	The group of teachers is coordinated by the teacher of Physics with all the teachers of the first two years of the STEM Department with a collaboration of the Italian teacher. Since they are teachers of the "biennium" (grade 9-10), they aim to start working at a level of curriculum within the context of STEM civic education (*) for pupils of grade 9 and 10 but with the larger to scope to create a trial that can be extended also to the teachers of the "triennium" (grade 11-12-13). They also work within the context of STEM civic education (*). ***Stakeholders:*** teachers of the "triennium", teachers of other schools coming from the province, disciplinary experts, families.
Liceo Scientifico A. Einstein (Rimini)	9	Physics, Math, Natural Science, Italian Literature	The group of teachers is coordinated by a teacher-research in Physics with all the teachers of the STEM Department with collaborations of the Italian teachers. Since this school is already active in terms of innovative extra-curricular activities, they participate in the project with the idea to put their expertise into a framing of sense and turn they innovative experiences into something more structural that can affect the curriculum in a deep way. They work on "contaminations" between disciplines and colleagues. They also work within the context of STEM civic education (*). ***Stakeholders:*** teachers of the school coming from very different disciplines especially from humanities, disciplinary experts.

ITAC Scarabelli-Ghini (Imola)	4	Natural sciences, Chemistry, English	The group of teachers is coordinated by a teacher-research in Chemistry with all the teachers who participate into a transversal group about environmental and sustainability education. They formed a small group with which they want to perform a small extra-curricular change that can be an example to be discussed into the school for activating more in advance a more structural change. *Stakeholders:* other teachers of the school, families, local entrepreneurs in environmental agency.

(*) All the schools situate their participation in relation with a recent ministerial change, influenced by European directives, dates back to 2020 when Civic Education was introduced for all school levels, starting from kindergarten up to secondary school, as a transversal teaching to all disciplines. According to ministerial indications, the teaching of Civic Education revolves around three main themes: i) CONSTITUTION, law (national and international), legality and solidarity; ii) SUSTAINABLE DEVELOPMENT, environmental education, knowledge and protection of heritage and the territory; iii) DIGITAL CITIZENSHIP. Teachers should address 33h per year per school classroom about civic education, among these they can organise the topic in an autonomous way but addressing at least 8h within STEM disciplines.

Within the Italian local network, concerning this first area, i.e. the assessment of *challenges and opportunities with regards to the establishment and implementation of open schooling partnerships*, we focus on the ChangeLab workshop methodology (D2.4) as well as the appropriation of SEAS tools by different contexts (D4.1). The focus in this area was guided by one broad question: *How can open schooling contribute to reimagining school science?*

The data collection was organised to monitoring the ***processes of interactions*** within the network and how the different groups of schools' teachers appropriate of the SEAS main ideas, concepts, principles and tools by re-interpreting and embedding them into their contexts. To follow this process, we collected the following data:

- Video- and audio-recordings of preparatory meetings
- Video- and audio-recordings of ChangeLab workshops
- Video- and audio-recordings of intermediate meetings
- Field notes of meetings
- Email exchanges and written conversation with teachers (*)
- Notes coming from oral informal conversation (*)

The last two sets of data represented sets of informal, unstructured, and un-recorded data coming from ***networking moments*** happened in between of official moments. These data were still considered rich and crucial because they emerged from needs of confrontation naturally happened across the whole process. Those data are still difficult to be processed because of their nature, since

they not represented data coming from a simple observation process but from interactive processes happened spontaneously.

All the formal data were collected during the network meetings. A roadmap of the formal meetings had within the local network is summed up in table 1.2. According with the rules given for the pandemic restrictions, almost all the meetings were organised online. However, this modality didn't reduce the interaction since we used shared spaces for materials exchange and storage (e.g. Google classroom, Google drive) as well as interactive platform for making workshops and activities (e.g. Zoom, jamboard, Miro). The only meetings which took place in person where the final events of the schools and the meetings with small groups of people happened during the summer period.

Table 1.2. Summary of local network meetings (from September 2020).

DATE	WHAT	WHO	TIME
September-October 2020	Preparatory meeting with schools	UNIBO with 3 schools and FG with 2 schools	1h or 2h meeting, once or twice per week
October 2020	Preparatory meeting of the ChangeLab	UNIBO and FG	1h or 2h meeting, twice per week
4/11/20 and 6/11/20	ChangeLab workshop	UNIBO, FG, CMCC, CLIMATE-KIC, 7 schools, 30 teachers (among whom 2 principals)	2 afternoons of 4h each
November – December 2020	Planning activities with the schools	UNIBO with 3 schools and FG with 2 schools	1h or 2h meeting, once or twice per week
January – February 2021	UNIBO iteration, observational contexts, and teachers' training	UNIBO with all the schools	3h meeting, once per week
February – May 2021	Iterations in the schools (asides activities agreed according with schools' needs)	3 schools (monitored by UNIBO) 2 schools (monitored by FG)	1h or 2h meeting, once or twice per week
11/05/21	Moment of alignment	UNIBO, FG, CMCC, CLIMATE-KIC, 7 schools, 30 teachers (among whom 2 principals)	3h
May 2021	Final events in the schools	UNIBO with 3 schools and FG with 2 schools	3h meeting with each school
June 2021	Synthesis exchanges with the schools	UNIBO with 3 schools and FG with 2 schools	2h meeting with each school
September 2021	Preparatory meeting with schools	UNIBO with 3 schools and FG with 1 school	1h or 2h meeting, once or twice per week
September 2021	Preparatory meeting of the ChangeLab	UNIBO and FG	1h or 2h meeting, twice per week

1/10/21 and 5/10/21	ChangeLab workshop	UNIBO, FG, 4 schools, 40 teachers (among whom 2 principals)	2 afternoons of 3h each
November – December 2021	Planning activities with the schools	UNIBO with 3 schools and FG with 1 school	1h or 2h meeting, once or twice per week

Analytical procedure and approach

The data collected to follow open schooling network dynamics were analysed through methods rooted in ***Grounded Theory*** (Anfara et al., 2002), which we generally apply in the analysis of data collected through qualitative methods, like interviews, focus groups, collective discussion, etc. (Levrini et al., 2019). Particularly, from Grounded Theory we used the ideas of ***theoretical sensitivity***[28] (Glaser & Holton, 2004) and ***sensitizing concepts***[29] (Charmaz, 2003). Moreover, we used these two pillar ideas of Grounded Theory also as design criteria to co-design and co-develop our local open schooling idea, indeed we used the synthesis of the findings coming from the analysis of the first-year network concerning this area (see D3.1) to assess, orient, re-define, re shape and re-design ideas aiming at growing up into our local network dynamics and identity. Therefore, Grounded Theory represented the general framework into which we moved when we referred to this area both in terms of analytical framework and in terms of a broader methodological framework.

More specifically, for the operative analysis of this area, we mainly refer to the Braun & Clarke (2006) approach to ***reflexive thematic analysis*** in a combination of top-down (*theoretical-oriented*) and bottom-up approach (*data-oriented*). The data were analysed through an iterative process that included bottom-up debriefing phases designed to identify the emergent aspects in the first-year network data and generate first interpretative ideas as well as top-down phases designed to exploit existing concepts and ideas to match against the data corpus. To reach an acceptable level of internal validity, the analysis was conducted through a triangulation process by involving researchers in science education and some collaborators of the network (Anfara et. al, 2002).

In particular, the analysis would incorporate the idea of determining what **tensions** appear (and need to be addressed) in the local context and about what strategies can be put into place to address them (Hedelfalk et al., 2020; Kapon et al., 2018).

Following the reflexive thematic analysis, we identified some tensions (in a mix of bottom-up and top-down procedure) and then we used the tension to go over the data and see: ***i) how those***

[28] Theoretical sensitivity is a key concept of grounded theory studies, as Glaser wrote is "*The ability to generate concepts from data and to relate them according to normal models of theory in general, and theory development in sociology in particular, is the essence of theoretical sensitivity. Generating a theory from data means that most hypotheses and concepts not only come from the data, but are systematically worked out in relation to the data during the course of the research*" (Glaser & Holton, 2004, p.43).

[29] *"Sensitizing concepts are those background ideas that inform an overall research problem. […] Sensitizing concepts offer ways of seeing, organizing and understanding experience. Although they may deepen perception, they provide starting points for building analysis, not ending points for evading it"* (Charmaz, 2003; p.259).

tensions have been manifested; ii) in what way the tensions were addressed. The analysis (still in progress) develops around the following phases:

- Phase 1: identification of some important tensions coming from the SEAS framework (and from the Bologna research approach) that oriented the design processes within the local network;
- Phase 2: re-reading of the data coming from the first year of the project and recognition of main tensions, emerged as synthesis of previous findings;
- Phase 3 (*in progress*): (rough) definition of the tensions;
- Phase 4 (*in progress*): matching of the tensions against the corpus of data so as to: i) refine the definition of the tensions and find representative examples; ii) reach a (reasonable) level of saturation concerning the tensions.

Findings

As we have already made explicit in the previous paragraph, some phases of this analysis are still in progress but we will sum up in this section the preliminary results obtained from the analysis.

The main finding coming from Phase 1 and 2 is represented by the definition of what is a tension and the kind of phenomena can identify a tension, the identification and the naming of the actual tensions we are conceiving within the network as well as the design of a map of the tensions.

The tensions are visible when there is the manifestation of a phenomenon of polarisation. Like in a dipole where at the extremity there are objects of opposite nature (e.g. positive and negative electric charge) and there can be a privilege orientation toward one extreme or another, the tension emerges as the results of a dynamical equilibrium which let overcome the collapse on one of the pole but, at the same time, is a phenomenon alimented by the existence of the polarisation itself.

This *dynamical balancing* which characterises the nature of the tensions gives them the power to support the coexistence of multiple possibilities that doesn't require to be solved into a unique and static solution.

Among the tensions we conceived within the network, we tried to name them and organise a map of where they belong to. The map of the tensions with the traced of their belonging is shown in Figure 1.1.

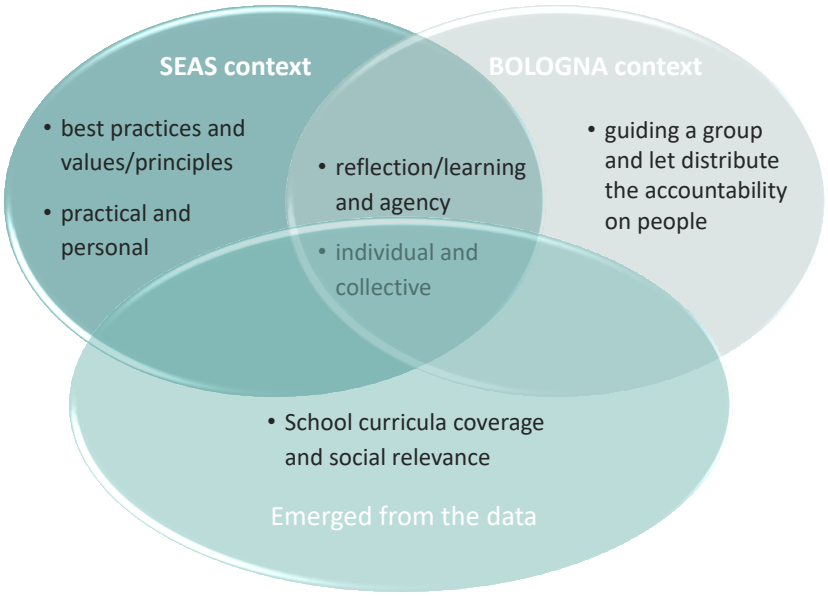


Figure 1.1. Map of the tensions

(***Legend:*** the tensions belonging to SEAS and Bologna contexts were considered the ones who already existed *a-priori* as part of theoretical background of the proposal and the local research approach; the tensions emerged from the data are the ones that emerged only *a-posteriori* across network life; the tensions in the intersections are the ones which were recognisable as important *a priori* but that strongly emerged more nuanced *a posteriori*).

The recognition, identification and mapping of the tensions was performed through an iterative process of clustering and cross-checking of recurrent ideas, concepts, words which describe recurrent attitude, needs and problems pointed out by the teachers. For building up this picture we mainly used data coming from small meetings (intermediate meetings with single schools, preparatory meetings, reflective meetings and fields notes) which have the feature of being more meta-reflective.

The main findings coming from Phase 3 and 4 (*both still in progress*) contribute to the definition, refinement and saturation processes related to the set of tensions (see Table 1.3). Since the work is still in progress, we cannot assert that the saturation process has been already reached out.

Table 1.3. Definition of the tensions.

Tension	(rough) definition
Best practices and Values/Principles	It concerns the importance of working at a level of realising and carrying on practices within a classroom and the importance to concentrate at a level of affecting the values and the principles which guide a process.

Practical and Personal	It concerns the importance of changing by acting at a level of behaviours and acting at a level of views and perspectives. (* It is intended as that tensions which mirrors the model of the three spheres of transformation)
Reflection/Learning and agency	It concerns the importance of finding a personal relevance and meanings in the idiosyncratic process of learning and engaging with a theme and the *"the ability and the will to influence positively proper lives and the world/society around"* (OECD, 2018).
Individual/ Collective	It concerns the relevance of influencing and acting on individual process of change and trigger a collaborative process which is able to take the pace of the collective progress.
Guiding a group and let distribute the accountability on people	It concerns the importance of having a centralized dynamic that lead the whole group aligned on the same pace with the responsibility put on a group leader and the importance of leaving spaces of freedom to the individual to act independently and take the whole responsibility.
School curriculum coverage and social relevance	It concerns the importance of covering the school science programmes related to curricular indications and for which there are achievements to be reached across the school learning path and the importance of dealing with issue that address real complex societal problems.

The definition of the tensions was performed with an iterative process of matching the definitions against example of data. For building up this picture we mainly used the data coming from the video-recordings of the ChangeLab Workshops. These data were particularly meaningful for this analysis since they represented synthesis meeting at large participation of the teachers where there is also a more structured template of work and activity under the hat of shared aims.

Even if the analysis is in progress and we have not completed the saturation process, there are some crucial points that can be synthetised as broad findings:

- Even if the tensions represented a research outcomes, the language introduced by them highly resonated within the network and started to be part of a shared language for referring to (these tensions are all recognizable both in the local contexts of the schools which composed the network)
- The groups of teachers demonstrate, more or less explicitly, to recognise the appearance of these tensions and to put into action some strategies for dealing with them.

Operatively, to turn the set of the tensions into an instrument for helping in point out how the tensions can both be manifested and addressed, we have tried to identify some exploratory questions which can be refined and made operative in the future with the aim to represent a a template for guiding the teachers into interpreting and navigating them.

To make this pilot exercise we consider a tension strongly present in the data coming from the last ChangeLab Workshop (October 2021): ***Tension between school curriculum coverage and social relevance***. In particular, two schools of the network (mainly) strongly worked on the issue of integrating SEAS themes, ideas, concepts, principles and tools within the standard curricula. The real challenge was to rethink, de-structure and con-structure curricular topics so as to embed the societal relevance of topic like sustainability and climate change into official curricular. The description of the tension with associated questions which can be raised for addressing this tension are the following:

Tension between school curriculum coverage and social relevance	It concerns the importance of covering the school science programmes related to curricular indications and for which there are achievements to be reached across the school learning path and the importance of dealing with issue that address real complex societal problems. It raises the following questions: *How it is possible to root STEM interdisciplinary and multi-dimensional topics within the different school subjects? How it is possible to switch on a societal dimension …*

This tension appears to be particularly important since it raises an important issue: the ***redefinition of the role of the teacher*** in terms of relationship with knowledge, fields of competences and consolidated practices, school' constrains and colleagues. Here an excerpt from a teacher arguing about this: *"Setting up a (difficult) work of sharing common ground with colleagues, convinced of the need to make some STRUCTURAL paths for our school, so that they reveal the school's imprint"* (Teacher form Liceo Einstein).

Conceptual model(s)

To interpret the findings related to the tensions emerged from the Italian open schooling network and, particularly, to the last tension discussed (***tension between school curriculum coverage and social relevance***), we have identified some theoretical models which can be used for situating the re-definition of the role of the teachers raised by this tension.

Finding a dynamical balance between covering school curriculum with respect to a specific discipline and give to school teaching a social relevance is strictly related to an effort required to the teachers in positioning with respect to knowledge, fields of competences and consolidated practices, school' constrains and relations among colleagues.

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. For example, the teachers who experienced the **tension between school curriculum coverage and social relevance**, explain the boundary experience in that way:

> *"The things we teach at school, even from a scientific point of view, acquire meaning and have a value if they become a tool for understanding the reality in which we live, not only to know how to understand and interpret it, but if science provides us with the also tools for acting in society. Because understanding is one thing, having the tools to take concrete actions is one thing. And so let's say that we (teachers) trusted you (researchers) who made us this proposal, we went out of our comfort zone and tried to collect different inputs, then we went back to school and we said how we could talking to students about the subject of complexity, and we explored this world of complex systems science a bit, until we found our key to re-reading it and integrating it into our programs. We did it to see what kind of change a science teaching of this type could bring about on students who had instead always experienced a traditional type of teaching and if this could open up new perspectives for them and make science relevant to their stay in the world."* (Teacher from ITAERFO)

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[30] (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***[31] 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

[30] 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).

[31] 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.

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.

(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.

Implications to updating and differentiating SEAS concepts, tools, and methods

As we anticipated in the first paragraph (1.1), within the Italian local network, concerning this first area, we focus on the: i) appropriation of SEAS concepts, ideas and tools (D2.1, D2.2, D2.3, D4.1) as well as the ii) re-interpretation of the ChangeLab workshop methodology within our local research context (D2.4). In the next two paragraph we will describe how we have work on these two aspects.

Appropriation of SEAS concepts, ideas and tools

As starting point, the Italian local network bases its activity on the implementation of modules designed in a previous Erasmus+ project called I SEE[32] whose aims were to develop skills for imagining the future and aspire to STEM careers and to foster students' identities as capable persons and citizens in a global, fragile and changing world. The modules are based on an educational reconstruction of cross-cutting scientific topics, such as Climate Change, Artificial Intelligence, Quantum Computer, Carbon Sequestration, which are likely to be important in students' futures, both at the personal, vocational and societal level.

These modules were thought to develop special skills through science education, in and out of school: they are called future-scaffolding skills and refer to the ability to construct visions of the future that empower action in the present with an eye on the horizon (Levrini et al., 2019: 2021). The challenge of developing future-scaffolding skills through science topics, combined with the innovative pedagogies based on the action competence, encounters the core of the SEAS project

[32] I SEE – Inclusive STEM Education to Enhance the capacity to aspire and imagine future careers (PROJECT NUMBER - 2016-1-IT02-KA201-024373, September 2016 – August 2019). PI: Olivia Levrini, University of Bologna (https://iseeproject.eu).

of supporting young people (and others) to develop sense-making resources and transformative engagement in and through addressing complex sustainability challenges.

Despite this favourable starting point that delineated a *trait d'union* between the SEAS main ideas and our previous local approach, we however needed to activate a first change of perspective and develop some criteria for appropriating the ontological and epistemological sense of SEAS concepts.

The main issue we encountered concerned the shift we did in moving our 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 our 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 crucial references the bunch of 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".

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.

Identifying Dilemmas

We can say that the main dilemmas emerged from the Italian open schooling network are quite good synthetised by the tensions emerged as results of the analysis.

In this sense we report here table 1.3 which describe these tensions:

Tension	(rough) definition
Best practices and Values/Principles	It concerns the importance of working at a level of realising and carrying on practices within a classroom and the importance to concentrate at a level of affecting the values and the principles which guide a process.
Practical and Personal	It concerns the importance of changing by acting at a level of behaviours and acting at a level of views and perspectives.
Reflection/Learning and agency	It concerns the importance of finding a personal relevance and meanings in the idiosyncratic process of learning and engaging with a theme and the *"the ability and the will to influence positively proper lives and the world/society around"* (OECD, 2018).
Individual/ Collective	It concerns the relevance of influencing and acting on individual process of change and trigger a collaborative process which is able to take the pace of the collective progress.
Guiding a group and let distribute the accountability on people	It concerns the importance of having a centralized dynamic that lead the whole group aligned on the same pace with the responsibility put on a group leader and the importance of leaving spaces of freedom to the individual to act independently and take the whole responsibility.
School curriculum coverage and social relevance	It concerns the importance of covering the school science programmes related to curricular indications and for which there are achievements to be reached across the school learning path and the importance of dealing with issue that address real complex societal problems.

Reporting area 2, Italy: Challenges and opportunities to transformational engagement, scientific literacies, and motivation

Methods

Data sources and Participants

Within the Italian local network, concerning this second area, i.e. the assessment of *challenges and opportunities to transformational engagement, scientific literacies and motivation*, we focus on the analysis of the iterations, that are represented by the implementations of activities with the students.

The second year of the project was very fruitful, indeed the schools were able to carried out multiple iterations. As for the first year, we had a common iteration which was a common ground around which we built together ideas within the network, we see some activities into action and we experimented the tools. This iteration was implemented within the context of *Piano Nazionale Lauree Scientifiche* at the Department of Physics and Astronomy of the University of Bologna and implemented along 6 afternoons (once per week) in the period of January-February 2021 and November-December 2021. Table 2.1 shows a summary of the iterations.

Table 2.1. Italian open schooling network iterations.

School/ Context	Classes/ groups	Stud N.	Grade & age	Teachers N.	Disciplines involved	Position with respect to curricula	(SEAS) Tools
PLS at University (* COMMON ITERATION)	1 heterogeneous class from students coming different schools across the region	37	Grade 12-13 (17-18 y.o.)	4 experts and 6/7 teachers	STEM (climatology, physics, complex science, math), language (for text analysis, and societal	Extra-curricular	cCHALLENGE, casual maps, role-play simulation, ChangeGame, analysis of scenario
Istituto Comprensivo of Meldola (FC) (K-8 curriculum)	4 classes within the same school	80	Grade 8 (13-14 y.o.)	5	Science, Technology	Curricular	cCHALLENGE, causal maps
ITAER Baracca of Forlì (FC)	2 classes splitted into mix sub-groups	60	Grade 10 (15-16 y.o.)	5	Physics, Chemistry, Natural Sciences, Italian	Curricular	Scenario building, Causal map, Role-play simulation, Argumentative text, ...

Liceo Scientifico A. Einstein (Rimini)	3 classes	75	Grade 9 & 10 (14-16 y.o.)	9	Natural Science, Physics, Math, Italian	Curricular	cCHALLENGE, creative writing and storytelling
ITAC Scarabelli-Ghini (Imola)	1 class	20	Grade 9 (14-15 y.o.)	4	Natural sciences, Chemistry, English	Extra-curricular	cCHALLENGE
Liceo Ginnasio statale Minghetti (Bologna)	1 class	20	Grade 10 (15-16 y.o.)	1	Natural Science	Extra-curricular	cCHALLENGE
International Experiential School (Reggio Emilia)	1 class	20	Grade 12 (17-19 y.o.)	1	Physics and Math	Curricular	Causal map, ChangeGame and Scenario building,

Through this teaching and practical experience, we collected the following typologies of data (Table 2.2).

Table 2.2. Summary of data collection.

Questionnaires	This typology of data involved all the direct questionnaires were asked the students to answer. They consist of pre- and post- questionnaire about activities or tools (e.g., cCHALLENGE) and general final questionnaire about the whole iteration. The questionnaires were composed of close-ended and open-ended questions which aim to investigate various dimensions touched by the activities of the course and the use of such special tools. There were also questions which ask the students to self-reflect and self-position on specific aspects, like for example their level of awareness and knowledge with respect to the themes touched in the course (e.g., climate change, sustainability, corban sequestration).

Artifact collection	This typology of data involved any artifact produced by the students during the whole course, including blogposts collected on the cCHALLENGE platform (digital or not), written boards and/or sheets used for sharing tasks during the lessons and/or support students in fixating their thoughts and/or positioning with respect a collective questioning activity, written maps or text documents, assessments, final activities produced collectively by the classes, etc.
Classroom observation	This typology of data involved the audio- and video-recording of the lessons, the groups' work and the collective discussions taking place during the course as well as field notes and diary boards written during the debriefing sessions taking place among the researchers after each lesson.

The instruments illustrated in the table were used for collecting data in what we call "common iteration", a teaching/learning course about climate change that we develop as common implementation of the network. Some of these instruments were however still used also in the implementations carried out by each group of teachers within the different schools.

For the analysis of this area, we mainly considered the common iteration as emblematic case of our network.

Analytical procedure and approach

The whole local approach concerning this area is framed within the Design Based Research (Cobb et al., 2003) aimed to develop, test, and revise teaching activities and materials that implement the SEAS main principles, ideas, concepts and tools and research results coming from the first-year iterations.

This common iteration triggered a process of co-design of teaching materials and activities that have been then implemented in the diverse contexts of the different schools.

From a methodological point of view, two main features of design-based research (Cobb et al., 2003; Plomp & Nieveen, 2013) make this framework particularly appropriate for the goals of the project: the iterative dynamics it involves and its theoretical orientation. The development of the materials and activities was indeed carried out through an iterative process of designing, testing, revising, according to a back-and-forth dynamics between theoretical hypotheses and empirical results. This process informs the way of materials production such that it does not follow a linear process (preparation, implementation and evaluation) but a back and forth, multiple rounds, dynamic process of revision and refinement. The results of the process are not only an improvement of the materials, but also – and mainly – a "theoretically-oriented" evaluation of the impact of the implementations on students' processes of knowledge and skills development.

As for the first area, the data have been collected from different sources and analysed by qualitative methods of data analysis rooted in ***Grounded Theory*** (Anfara et al., 2002), which we generally apply in the analysis of interviews, focus groups, collective discussion, etc. (Levrini et al., 2019).

Through these methods we aim to highlight not only what happened in a specific teaching/learning experience but also to provide an interpretation of *why*, *when* and *how* that happened (Plomp & Nieveen, 2013). Such orientation of the analysis aims to maximise the materials' transferability in different contexts.

Given the nature of the data, which include also questionnaires with close-ended or likert-sclae questions, we opted for a **semi-qualitative methodology** of data analysis (Anfara et al., 2002). In particular, we assume the approach of ***reflexive thematic analysis*** where a **mixed inductive/deductive operative** way of looking at the data and highlighted themes is used, combining both data-driven clustering and theoretical hypothesis (Braun & Clarke, 2019).

The analysis (still in progress) develops around the following phases:

- Phase 1: analysis of the close-ended questions of the questionnaires for giving an overall picture
- Phase 2 (*in progress*): analysis of answers to open-ended questions, students' talks during collective discussions and students' blogpost on the cCHALLENGE platform (grouped into an excel file) and analysis of the final products
- Phase 3 (*in progress*): matching of a model of agency (e.g. Model of the Three Spheres) against the corpus of data in order to see how the three dimensions are manifested

The analysis aims to answer the following questions: *RQ1a) How teaching/learning climate change in Physics can embed SEAS principles, ideas and tools? RQ1b) To what extent does the module impact on students' perception of themselves as agents of change? RQ2) What kind of supporting structures represent ways for triggering dynamic relationships between individual attitudes and a collective dimension?*

Findings

As excerpt of findings related to this area, we will focus on the common iteration. Due to the nature of this network, the results relating to this area are into two direction:

- the co-design of the module, activities, tools, and materials implemented in the iterations (RQ1a; RQ1b))
- the analysis of the impact of the module (RQ1b; RQ2)

Finding 1: The module.

According with the approach described into section 1.2.2, we revised and co-designed within the network a module on climate change that was implemented with groups of students and that represented our "common iteration".

The module was organized in a multi-layered structure that considered some important characteristics of the theme of climate change (Tasquier et al., 2016; Tasquier & Pongiglione, 2017; Levrini et a., 2019; Tasquier et al., 2019; Levrini et al., 2021). Indeed, it is a topic that is:

- *Complex*, because the climate is itself a "complex system" resulting from the interactions that occur on an enormous variety of spatial and temporal scales between the various and many sub-systems that compose it; in fact, in a complex system the interactions between the components of the system can follow not only a linear cause-effect logic but also a circular cause-effect logic in which one component acts on another and this, in turn , it feeds back on the former;

- *Multi and inter-disciplinary*, because it involves many scientific disciplines, among which, climatology, meteorology, physics, chemistry, biology and so on, this means that there are many conceptual difficulties that hinder students' understanding of the scientific contents related to climate change, like Greenhouse Effect, and all of these have different epistemological models that belong to the feature of the disciplines;

- *Multidimensional*, because it doesn't touch only the scientific dimension but it also involves political, economic as well as personal, affective, psychological, ethical, etc. dimensions;

- *Multi-scale* since the causes and consequences are placed on different spatial-temporal scales and because it concerns decisions and actions both locally and globally and it is not easy to recognize the role of individual as a causal agent in such a complex dynamic system;

- *Future-oriented and future-relevant*, because it represents a widely debated social challenge for its implications for the future and its analysis to develop skills to imagine possible and desirable futures and is guided to use such images of futures as a driving force in their life, in order to activate their resources, engage in social challenges and guide their choices and actions in the present;

- *Transformative*, because responses to climate change require a combination of technological innovations, institutional reforms, behavioural shifts and cultural changes; those changes require a shift from a vison of people as objects to change to people as subjects of change in a genuine and mutual relationship with the environment.

The overall structure and agenda of the module is summarised in Figure 2.1.

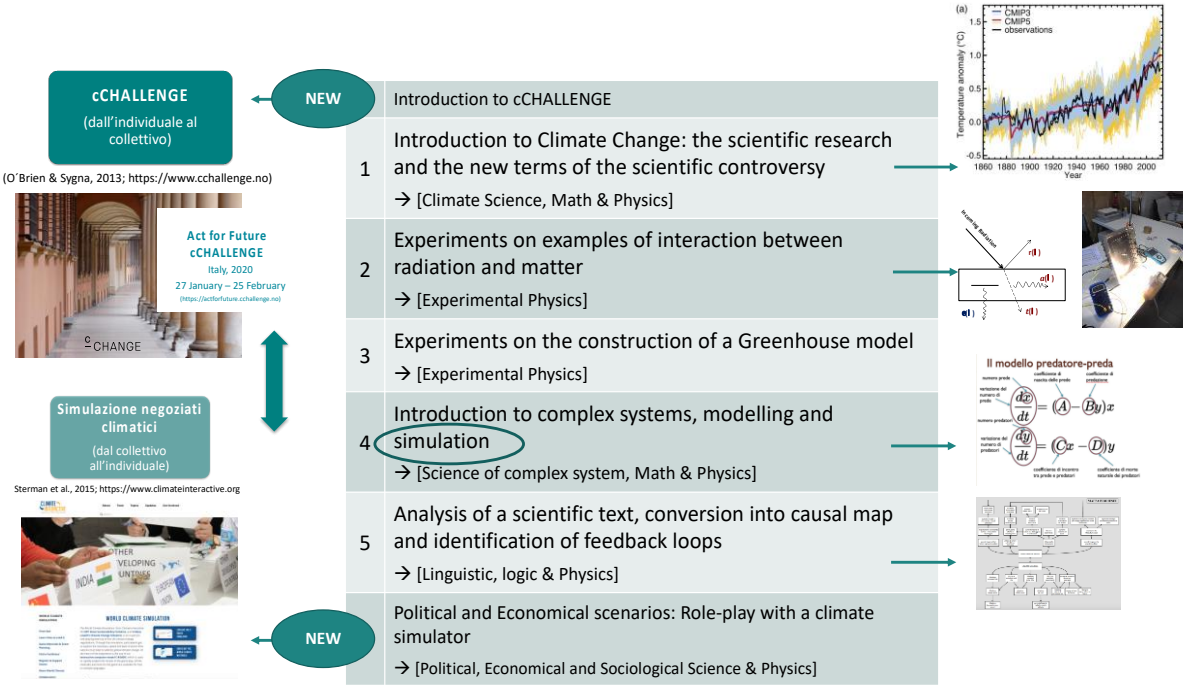


Figure 2.1. Overview of the module.

The core of the climate change module is represented by: i) a climate science lesson, where IPCC scenarios are discussed; ii) two laboratory activities on an experiment dedicated to radiation-matter interaction and an experiment dedicated to the construction of a model of the greenhouse effect; iii) a lesson on complex systems, simulation and modelling and an analysis of scientific texts (re-adapted by the IPCC) with text conversion into causal maps with discussion of feedback within the maps.

In order to embed and exploit in the module the transformative dimension, four activities related to tools were integrated into the course agenda, taking supplementary roles:

1) the cCHALLENGE platform, implemented within SEAS project by the cChange research centre in Oslo (Norway) (O´Brien & Sygna, 2013; https://www.cchallenge.no);

2) the role-playing activity World Climate: A Role-Play Simulation of Global Climate Negotiations developed by Climate Iteractive at MIT Sloan in Cambridge, Massachusetts (US), called c-ROADS (Sterman et al., 2015; https://www.climateinteractive.org/tools/c-roads/);

3) the "ChangeGame (https://www.changegame.org): The science-based game for confronting the challenges of climate change;

4) the SSPs Climate Scenarios (https://climatescenarios.org/primer/socioeconomic-development/): "*Shared Socioeconomic Pathways*" (SSPs) which represent five different narratives in which the world might evolve and how different levels of mitigation could be achieved.

As it is shown by figure 2.2, these tools were thought to activate a particular back and forth dynamic between individual action and collective impact, by giving support to the agentic role of individuals in shaping the system.

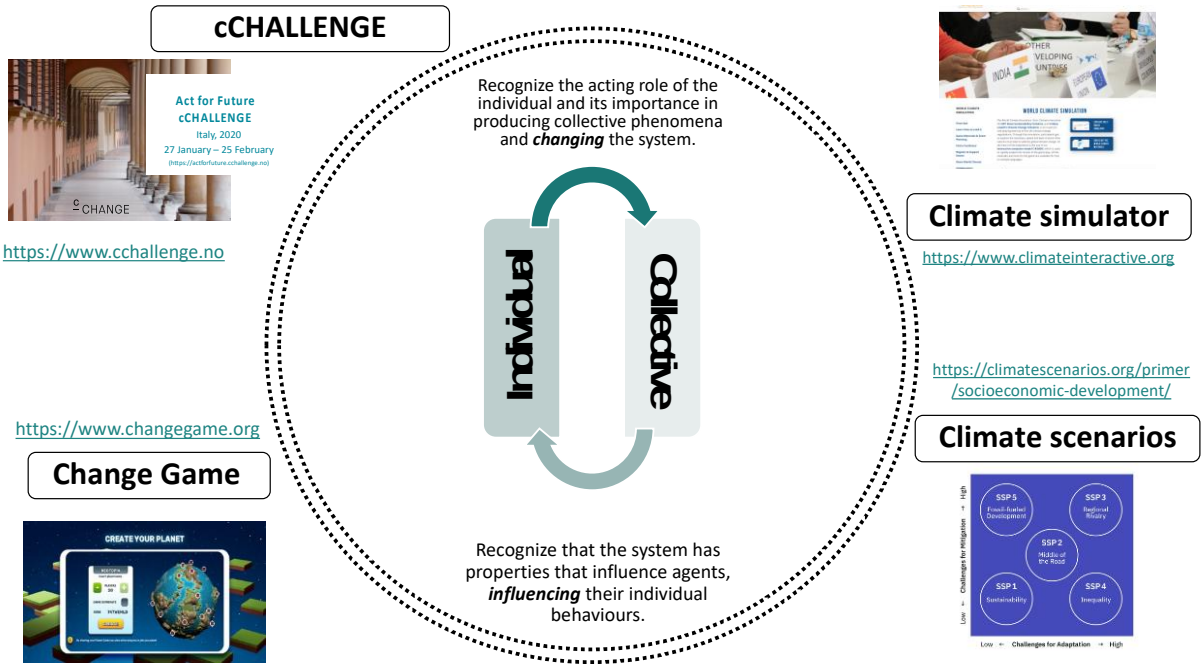


Figure 2.1. The schema of the tools.

cCHALLENGE is a tool aiming to trigger a reflexive and experimental process for transformative learning, focusing on the relationship between individual change, collective change and system change. The method is based on the heuristic model of the three spheres of transformation (O'Brien & Sygna, 2013), and invites students and teachers to explore how change happens through changing a habit for 30 days. The change experiments allow them to notice their influence on others by sharing their stories, and to explore their own role in changing unsustainable systems and practices. The cCHALLENGE tool is originally conceived as a digital platform but across the project a *Paper&Pen* version was also developed. Thanks to the sharing space of the platform, participants from different contexts collaborating in joint projects can share narratives as blogs, describing possible solutions, new ideas and courses of action together with evidence of change. cCHALLENGE fosters collaboration, co-creation and dialogue among the local actors involved in the challenge, and generates new stories about solutions and the role of people within the climate dynamics. By sharing insights and stories on the multi-media digital platform, participants become increasingly aware of new patterns and possibilities, serving as a scientific inquiry tool. Emerging *narratives of change* become visible and shareable as textual objects, that mediate both individual and collective learning

in learning trajectories across places, time, and encounters with experiences of phenomena, people and texts. (Knain et al., 2021).

Through engagement in cCHALLENGE activities, the students experimented with personal change through 30 days projects that are followed up during and after the 30-days period in classroom and out-of-school activities. The students of this implementation have experienced the cCHALLENGE tools from January 27th to February 25th.

C-ROADS is a free computer simulator that has the aim to help individuals understand the long-term climate impacts of national and regional greenhouse gas emission reductions at the global level. This tool is suggested to use as part of the "World Climate Simulation", an interactive role-play where the young can play the roles of UN climate negotiators working to create an agreement to limit global warming. Participants play the role of negotiators for various nations (or blocs of nations) and they must consider their national interests as they negotiate a global agreement to mitigate climate change. To do that, participants receive briefings to help them understand the national interests and objectives of the nations they represent. During the simulation, they play some rounds where they negotiate with one another to agree on commitments for GHG emissions reductions from the present through 2100, long enough to capture projected population growth, economic development, and important climate impacts (Sterman et al., 2014). During the role-play, students were guided toward the following stages: i) Allocation of roles linked to groups of countries or stakeholders that take part in climate-related decisions (e.g. non-governmental associations, oil industries, etc.); ii) In-depth analysis of related data of countries and stakeholders; iii) Negotiation between the parties to decide which measures to take and on what time scale iv) Data introduction into the simulator and projection of scenarios; v) Renegotiation of objectives based on scenarios.

C-ROADS was used to help the students to move from their individual challenge to a collective perspective and then to come back to evaluate their challenge with new perspectives and insights. In this sense, the interaction between cCHALLENGE and C-ROADS aimed at activating a back and forth dynamic between individual and collective aspects.

ChangeGame is a technological innovative tool which aim to facilitate the understanding of climate change, indeed is a science-based game for confronting the challenges of climate change. It was conceived and produced by the Euro-Mediterranean Center for Climate Change (CMCC), in collaboration with MelaZeta and CLIMATE-KIC, with the specific contribution of Eleonora Cogo who greatly contributed to the design and implementation of the experiment.

It is a simulation video game, that is a game in which realistic environments are simulated and in which the gamer needs to create a specific strategy to perform the actions in the context of this simulation. Among simulation video games we can identify two categories to which the ChangeGame belongs:

- City-building game: that is a type of simulation video game in which the players build and are the leaders of a city.
- Business simulation game: that is the category of video game in which the players simulate the management of a given system (in our case the city).

The dynamics of the game are common to other video games, in fact, the user is asked to create a city within a world and the game develops in a first merely constructive phase, and in a second phase of upgrade and / or maintenance. . The peculiar aspect of ChangeGame lies, however, in the choice of parameters to be taken into account in the game: in essence, the novelty is the mechanism that is needed to win, and the unexpected events or actions that the game offers.

The objectives of the game are:

- Improve the understanding of the assumptions governing the Earth's climate system, the relationship between sources / sinks of GHG emissions and the effects of rising global temperatures on the planet
- Improve the understanding of the complexities of the climate system and its interactions with humanity and the natural ecosystem
- Stimulate reflection on what it means to become a zero-emission and climate-resilient society and what system innovations are possible/necessary

This video game aims to work on game dynamics on two aspects in particular: to raise awareness of climate change and lead the user, through the analysis of game dynamics, to the understanding of a key feature of the climate system, namely its complexity. . The ChangeGame allows, therefore, to better analyse some dynamics concerning complex systems: the built city, together with the actions carried out by the player, in addition to influencing the parameters seen above, presents mechanisms of feedback, nonlinearity and emerging self-organization behaviours, that is the characteristic behaviours of a complex system.

The SSPs Climate Scenarios come from the literature in climate science and they are part also of the forthcoming IPCC report (IPCC, 2021 & *forthcoming*). While the last IPCC reports (2013) showed "*Representative Concentration Pathways*" (RCPs), describing different levels of radiative forcing that might occur, the coming report is introducing "*Shared Socioeconomic Pathways*" (SSPs) which represent five different narratives in which the world might evolve and how different levels of mitigation could be achieved when the targets of RCPs are combined with SSPs. The SSPs (O'Neill et al., 2017) are based on five narratives describing broad socioeconomic trends that could shape future society. These are intended to span the range of plausible futures:

SSP1 - a world of sustainability-focused growth and equality

SSP2 - a "middle of the road" world where trends broadly follow their historical patterns

SSP3 - a fragmented world of "resurgent nationalism"

SSP4 - a world of ever-increasing inequality

SSP5 - a world of rapid and unconstrained growth in economic output and energy use

The SSPs offer a systematic exploration of possible socioeconomic futures in terms of widely different predispositions to mitigate and adapt to climate change. Socioeconomic challenges to mitigate vary, e.g., with the resource and carbon intensity of consumption. Socioeconomic challenges to adapt vary, e.g., with the level of education, health care, poverty and inequality in societies around the world.

For example, SSP1 and SSP5 envision relatively optimistic trends for human development, with "substantial investments in education and health, rapid economic growth, and well-functioning institutions". They differ in that SSP5 assumes this will be driven by an energy-intensive, fossil fuel-based economy, while in SSP1 there is an increasing shift toward sustainable practices. SSP3 and SSP4 are more pessimistic in their future economic and social development, with little investment in education or health in poorer countries coupled with a fast-growing population and increasing inequalities. Finally, SSP2 represents a "middle of the road" scenario historical patterns of development are continued throughout the 21st century.

These narratives describe alternative pathways for future society. They present baselines of how things would look in the absence of climate policy, and allow researchers to examine barriers and opportunities for climate mitigation and adaptation in each possible future world when combined with mitigation targets.

This scenario were part on an activity where we created some tasks to give ti the students in order to reading their games and strategies (in playing the ChangeGame) in terms of building different scenarios. Here is an example of tasks:

- Task 1: Read carefully the narratives of the 5 scenarios to choose which scenario is most representative of your game strategy and explain why.
- Task 2: Identify your "desirable scenario" (situating with respect to SSPs) at 2040, tell your success story, how you managed to realize your desirable scenario. In doing this back-casting operation, retrace the history of what happened, of the choices that led you to reach the scenario (and to solve the problems). Each student takes on their own role in the change (cCHALLENGE!!) and plays the role as stakeholder.

Finding 2: The impact of the module.

As we have anticipated, the co-design work was the main focus of the second year within our open schooling network. The findings presented here, are still very preliminary and the analysis is still in progress.

From the analysis of students' answer, we observed how constructively students referred to scientific knowledge. In multiple utterances, students draw upon scientific arguments that include reference to SSI considerations, as a means to elaborate on their motivation and drive to pursue change. Indeed, they often showed awareness in supporting the sustainability challenge not merely by taking up on recommended practice of reducing meat consumption, but by drawing on the wealth of disciplinary knowledge on the subject, e.g.:

> *"In my challenge I have chosen to reduce the consumption of meat. A friend of mine have lent me some books and reading them I inquired about how to have a balanced diet even reducing meat consumption. I have made a food culture thanks to these books. They are not books written by radical people. I liked them and they gave me a lot of confidence because they are books by university professors who are experts in nutritionists, all balanced people who made me find a way to approach a diet with little meat, so in the end it is not such a difficult challenge -SF".*

Recognising the central role of scientific knowledge for interpreting climate change seemed to create a bridge between the urgency of the problem they perceived from the public debate and the need to give it a meaning by grounding it in the discipline. Understanding the problem by situating it within the learning of science gave substance to their interest and made them find arguments for defending their position not only in terms of a significant ideological choice, e.g.:

> *"Honestly, I realized that it is not that easy to change a habit and that it takes solid motivations. I found them in what I was studying in this course, in how the climate data was presented to me, in the fact that I understood the role of the atmosphere in the global warming, and I was able to connect the change in the atmosphere with the role of our global actions. The feedback mechanisms helped me to understand that in the cause-effect links between the single element and the community there are effects of balance or amplification. This helped me in finding valid motivation – SM".*

So, the relationship with scientific knowledge was established in two ways, on the one hand the scientific knowledge about climate change they were acquiring across the course served as a motivational factor for the challenge, on the other hand the challenge was experienced as a way for going more in depth into specific aspects related to climate change.

In referring to knowledge, there was another element of continuity. Indeed, an interesting aspect is that the students didn't refer only to the construction of a new knowledge produced thanks to the course but also to an alignment with previous knowledge that they have implicitly acquired and that was not recognised as meaningful for interpreting the issue. However, as a pattern that is

recognizable in the data, in those moments of alignment with previous knowledge, the students refer always to a knowledge acquired outside school science classes, and mainly through in-depth readings that they made for a personal scientific interest during the extra-school time.

A second aspect, recognizable as a pattern, is the ability of the students to recognize a plethora of different actors who may have different roles in addressing the climate problem, like for example the importance not only of the role of professional experts but of political decision makers and citizens, as exposed by this sentence. Recognising the multi-dimensional and multi-actor nature of the issue led them to identify that in the collective dynamic it is important to distinguish a variety of drivers of change that can act at different scales. We notice that the identification of the possible dimensions of actions as well as the types of actors, roles and communities represent an important factor for distinguishing where and how is possible to impact and for creating a sense of empowerment with respect the issue, e.g.:

> *"Who you are identifies your responsibilities, your role as an individual determines the weight of your choices. I took up the challenge as an 18 y.o. and my responsibility was to find a way to change a habit and generate a ripple effect in my communities (friends, family, classroom). The teacher of the course, for example, brought an educational message about the climate to a lot of students like me who did not know each other and who spread it to others. The teacher who made us play with the simulation on the climate negotiations is in charge of negotiating at the COP, if you carry out an agreement in those contexts this has enormous consequences on the countries. If you are a politician your challenge is to decide how to invest your country's money, whether to invest in renewable energy or other and this has an impact not only on your country but also on the global balances. The scale you act on depends on who you are, but I understand that what you do as individual has consequences on the collective dynamic – SM".*

In this example, the aspect of recognition triggered the creation of new relationships across the three spheres by including individuals as actors in the problem. However, the issue of who should drive the change or be responsible of it, remained an aspect of polarization between global and individuals.

Another important insight gained during the whole course was the importance to include values into science. Particularly, we have already seen the interplay between cCHALLENGE and C-ROADS in making science-based decisions. However, the students underlined how there is also another aspect: science-based decision concerning SSI aspects cannot be considered neutral from a value perspective. The climate discourse implies the involvement and the opening of decision-making scenarios. The request to make choices both in the cCHALLENGE and in the role-play simulation about climate negotiations open toward the complexity of personal, social and affective values that are inherent to making decisions. In discussing about the possible impacts of climate change related to possible scenarios, the students realise the importance of recognizing the risk of a decision take any personal position in the face of climate data suggesting a need for action is however, more or less explicitly, a decision:

"The challenge made me understand that the time is coming when we have to make a choice and that to have an impact it will have to be made massively … absurdly, we are deciding whether to take advantage of the time we have left to live in a temporary economic comfort zone as long as we can and then suffer disaster when it arrives (hoping it will not be with us) or if we have the strength to give up something to radically change course for a greater common good. The difference is that this is not a family rule coming from my parents, the (climate) data tell me this – SF".

From the analysis, it was possible to build a story around three patterns that seemed able to trigger a relationship between the individual attitudes (e.g. their interests, behaviours, etc.) and a collective dimension (e.g. sense of community, shared values, etc.), that are:

(a) awareness in supporting climate change and sustainability challenge not merely by following a recommended practice in personal everyday life but by recognizing the wealth of disciplinary knowledge on the subject as a resource to be drawn on;

(b) ability to recognize a plethora of different actors who may have different roles in addressing the climate problem, like for example the importance not only of the role of professional experts but of political decision makers and citizens;

(c) recognition of the fact that inclusion of science-based decisions concerning SSI aspects cannot be considered neutral from a value perspective.

The analysis indicated a tendency for students to be more aware of individuals to cause climate change than to be part of the solution. We recognised that when those three elements happened, the students were able to make a shift that help them to connect knowledge to agency. Moreover, it suggests that the characteristics of students' contextual connections in their sense-making processes is an important area of research to further explore the interconnections between complex sustainability challenges, scientific knowledge and agency.

Conceptual model(s)

The revision and co-design of the module has at its basis the idea of transformative change at the core of the SEAS project. In particular, we build upon the heuristic model of the three spheres of transformation developed by O'Brien and Sygna (2013), itself developed as a heuristic integrating diverse approaches to transformation in response to climate change and examining the changes necessary for individuals and organizations to meaningfully address climate change (O'Brien & Sygna, 2013). According to this model, transformation is a process that takes place across three closely related, interdependent spheres: i) a practical sphere, which includes both technical and behavioural changes that contribute to the solution of climate change and sustainable issues; ii) a political sphere, which highlights the systems and structures that facilitate or hinder transformation and which includes the social norms, rules, regulations, institutions and infrastructure that define

how society is organized as well as the social and ecological systems and structures; and iii) a personal sphere, which highlights the importance of individual and collective worldviews, values, beliefs and paradigms that are at stake and which drive people's motives for practical and political action, shaping the ways that make possible both the enacting of behavioural and technical actions (i.e. practical sphere) and the shaping of systemic and structural layouts (i.e., the political sphere) (O'Brien & Sygna, 2013).

Concretely, the model informed the kind of tools we used and how they were implemented with the students (as it is explained in the previous section). In particular, even if all the tools we have used across the implementation were thought to autonomously foster the dynamic among the three spheres, each tools was used to position the students mainly in one of the sphere and put a particular emphasis on their characterising aspects. Indeed, the cCHALLENGE was used to activate the practical sphere, the climate simulator the political sphere and the climate scenarios together with ChangeGame the personal sphere. The dialague between the tools represented the back-and-forth dynamizing movement across the spaheres.

Implication to updating and differentiating SEAS concepts, tools, and methods

SEAS tools (cCHALLENGE) are used in a complementarity way with other tools within a design process that would:

- Keep anchored to discipline (in the way we use it, the cCHALLENGE does not work only on an agency conveyed by a behavioural dimension but opens an *epistemological dimension*)
- Keep together the model of transformation of the three spheres with the individual-collective dynamics through ***complexity*** (this is the way in which we combined the cCHALLENGE activity with role-play simulation and Changegame)
- Keep together a narrative that develops both towards ***scenario building*** and ***causal reasoning*** (the concept of feedback conveyed by the activity on complex maps and the idea of back-casting conveyed by the scenario analysis is an example of nexus between narratives and causal reasoning)

Identifying Dilemmas

The main tensions emerged from this area are:

Reflection/Learning and agency	It concerns the importance of finding a personal relevance and meanings in the idiosyncratic process of learning and engaging with a theme and the *"the ability and the will to influence positively proper lives and the world/society around"* (OECD, 2018).
Individual/ Collective	It concerns the relevance of influencing and acting on individual process of change and trigger a collaborative process which is able to take the pace of the collective progress.

There is also a tension between causal reasoning and narratives that we are not still able to define but that we guess to define when the analysis will be more advanced.

Reporting area 3, Italy: Challenges and opportunities to teaching scientific literacy

Methods

Data sources and Participants

Within the Italian local network, concerning this third area, i.e. the assessment of *challenges and opportunities to teaching scientific literacy*, we focus on the kind of transformation that are emerging in the schools. Particularly, for this report we focus on two case studies concerning two schools of the network.

Before entering in detail, we would specify that the nature of this area implies a level of elaboration that is still on due course within the network. Hence, the results will still stay at a more descriptive level since there are things in action that are under assessment.

However, within this area we are trying to answer the following research question: How *open schooling* contributed to reimagining teaching/learning scientific literacy?

The schools take in consideration in this area are the same already presented in the first area, however, we reported an excerpt of some information in order to contextualise the sample (Table 3.1).

Table 3.1. Information about two schools

ITAER Baracca of Forlì (FC)	7 teachers involved distributed between Physics, Chemistry, Natural Sciences, Italian Literature	The group of teachers is coordinated by the teacher of Physics with all the teachers of the "biennium" STEM Department with a collaboration of the Italian teacher. Since they are teachers of the "biennium" (grade 9-10), they aim to start working at a level of curriculum within the context of STEM civic education (*) for pupils of grade 9 and 10 but with the larger to scope to create a trial that can be extended also to the teachers of the "triennium" (grade 11-12-13). They also work within the context of STEM civic education. ***Stakeholders:*** teachers of the "triennium", teachers of other schools coming from the province, disciplinary experts, families.
Liceo Scientifico A. Einstein (Rimini)	9 teachers involved distributed between Physics, Math, Natural Science, Italian Literature	The group of teachers is coordinated by a teacher-research in Physics with all the teachers of the STEM Department with collaborations of the Italian teachers. Since this school is already active in terms of innovative extra-curricular activities, they participate in the project with the idea to put their expertise into a framing of sense and turn they innovative experiences into something more structural that can affect the curriculum in a deep way. They work on "contaminations"

		between disciplines and colleagues. They also work within the context of STEM civic education. *Stakeholders:* teachers of the school coming from very different disciplines especially from humanities, disciplinary experts.

The data analysed for this area are the data collected during the last ChangeLab workshop which are represented by the video-recording of the workshop, the presentations made by the teachers, the common board used during the workshop and field notes.

Analytical procedure and approach

As we have already discussed into depth, we moved within the methodological framework of Design Based research and Grounded Theory. To have an insight on that, refer to sections 1.2.2 and 2.2.2.

However, it is important to point out again that the findings of this area are presented only in a descriptive way since they represent elements that started in October 2021 and that are still in progress and will end up in May 2022. Due to this timing, we will present findings in terms of elaboration and co-evolution of ideas that led

Findings

The Changelab workshop analysed in this area was carried out with the following objectives:

- analyse the experiences of second-year project
- orient the network towards the third year of the project and keep it alive
- extrapolate and consolidate a "local model" of open schooling in relationship with re-imagining teaching/learning school science and scientific literacy
- imagine the change beyond the SEAS project

We asked the schools to critically present to the activities they have carried re-reading them in the light of one of the main ideas of the project and creating a narrative which should include the dynamics of change according to the model of the three spheres of transformation. Besides highlighting change in terms of the model of the three spheres, we asked them to make explicit also the kind of leverage points make the change possible.

To help the school in thinking about this re-elaboration we gave them this template:

WHAT -

- *What objectives and values of the project*
- *Which SEAS tools and materials did you use / adapt and how did you integrate them*
- *Which stakeholders have you involved*
- *What results have you achieved, both in terms of output and impact?*
- *What are the changes you have generated and what were the leverage points (the moments, the dynamics, the turning points) that led to the change.*

SO WHAT -

- What does what happened tell us, especially considering the three dimensions of change?
- Why does it make sense for my student students, for us teachers who have worked on it, for our school, for our social context and the world?
- What have we grasped that is important and significant?

NOW WHAT -

- How does the sense we have grasped orient us towards the future?
- What strategies and actions will we implement?

The presentations of the schools were very impressive about the richness of both ideas and practices they have put into play within their context. Reading the presentation with the lens of the model of transformation we have summarised the kind of change in the following way (Table 3.2):

Table 3.2. Types of change put into action by the schools.

	Type of change per target	Example of type of change per sphere
ITAER Baracca of Forlì (FC)	• ***Teachers:*** increased participation, building relationships between other teachers • ***Students:*** they felt more informed, and they increased awareness of their ability to act and affect the world • ***Institution:*** make structural changes within the official curricula	*"It is an interactive dynamic between political and cultural change. Through small (but strong) practices that we are triggering, we are shaking the pillars of the school. We have a principal who comes with us and supports us, so we can think big, we can trigger something structural that can trigger a cultural change capable of changing the school from the inside." (Teacher 2)*
Liceo Scientifico	• ***Students:*** a personal change that become a social change	*"It is a change from the inside to the outside of the school, from a personal point of view, for*

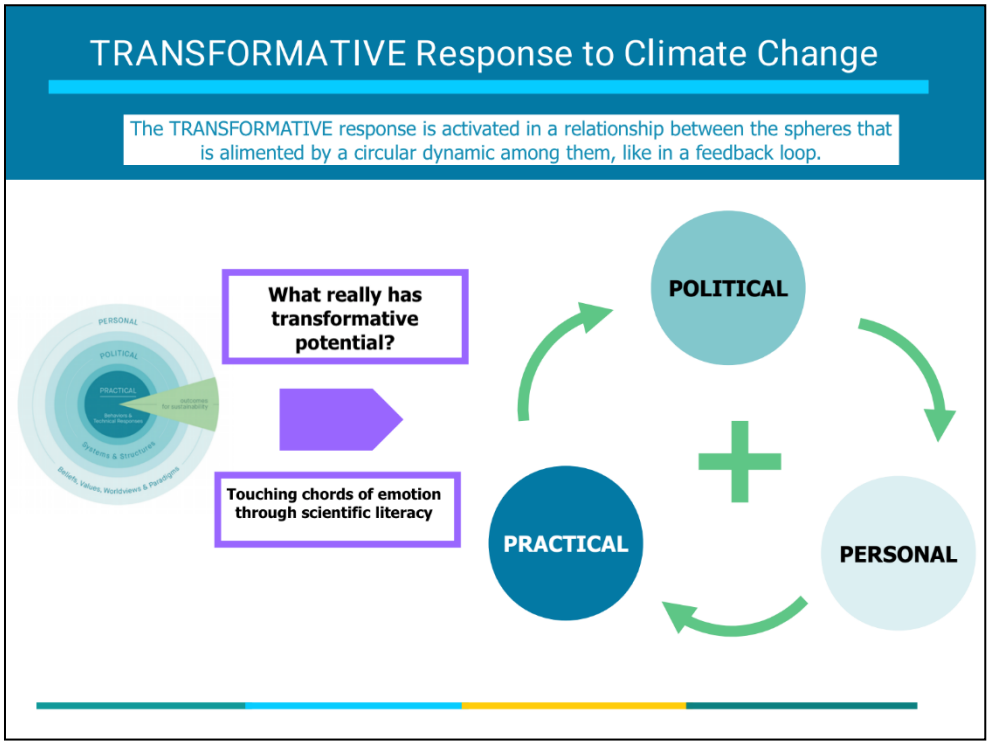
A. Einstein (Rimini)	• *Teachers:* more "intellectual trust" between each other, need to understand the different language of teachers coming from different fields. • *Institution:* introduce challenging topics in the discussion of the STEM department and in the collaboration with colleagues from humanities in some classroom councils	*both students and teachers who have to "intellectually trust" each other, with all that this entails in the comparison, in the understanding of language. Personal change is an engine that can trigger strong social change." (Teacher 3)*

Looking at the idea of transformation developed by these two schools, what emerged very clear is their appropriation and personal ri-elaboration of the meaning of transformation. Just to give an example, here an excerpt from a teacher and the visual ri-elaboration of the model of the three spheres made by another teacher.

Teacher 1:

"We want making projects that do not remain isolated episodes and special teachers involving only individuals. It is necessary to set up a (difficult) work of sharing common ground with colleagues (also and above all across the disciplines) with the conviction that it is necessary to make some STRUCTURAL paths for the school, so that they reveal the school footprint. Good practices are significant especially if they are framed in a framework of sense, only in this way we can think we are implementing a truly transformative action".

Teacher 2:



Trying to preliminary answer our research question: ***How open schooling contributed to reimagining school reality?***, we can borrow the words of Mr. Palomar of Italo Calvino, [change is] *"the window through which the world looks at the world" (Palomar, Calvino)*.

The open schooling idea make the schools, as institutions, *porous* to reality, that means it open toward their transformation in two ways:

i. from the inside outwards, the ability to look at what is happening outside and recognise that exist a *shared space of problems* that, like it or not, concerns the school as part of the system and as a place where cultural changes should be taken into action

ii. from the outside inwards, the ability to let external stimuli enter the school, like real complex SSI themes, that should influence and shape both the curricula and the global structure of the school

Conceptual model(s)

We interpret this finding as an example of how the model of the three spheres of transformation (O'Brian & Sygna, 2013) can be put into action into a school context and how it can inform scientific literacy.

As shown in our results, the changes fostered by the model of the three spheres were always used as a lens to re-think the way school science is re-shaped to embed societal relvance.

Implication to updating and differentiating SEAS concepts, tools, and methods

In terms of SEAS concepts, the two main ideas developed within this area are the concept of co-design and co-teaching as well as the idea of transformational change.

In this particular context, the co-design and co-teaching was identified as a model of interaction between teachers form STEM and teachers from humanities, in an attempt that would repositioning the knowledge as enrichment from multiple perspective and sensitivities. The new challenges posed by the society but also from the ministerial reform to the introduction of transversal civic education into the curriculum ask to make this effort in creating a model of interaction between STEM and humanities.

Within SEAS we are expected to trigger and support forms of deep transformation. In the project we have as reference the ***model of the 3 spheres of transformation*** (O'Brian & Sygna, 2013), this was locally used as starting point to specify/decline the key-words of the project in order to catch the

reality and the specificity of local experiences and be refined and re-defined as theoretical lenses for SEAS.

Identifying Dilemmas

Tracing back the tensions emerged from the first area, here we have identified the following tensions:

- Best practices and Values/Principles: It concerns the importance of working at a level of realising and carrying on practices within a classroom and the importance to concentrate at a level of affecting the values and the principles which guide a process.
- Practical and Personal: It concerns the importance of changing by acting at a level of behaviours and acting at a level of views and perspectives.
- School curriculum coverage and social relevance: It concerns the importance of covering the school science programmes related to curricular indications and for which there are achievements to be reached across the school learning path and the importance of dealing with issue that address real complex societal problems.

COVID-19 impact

Covid has both positive and negative impacts on the life of the network. Particularly the three main affections for the us were:

- Increase of engagement of the teachers in the project (COVID helped in distinguish between urgent things and important things)
- Logistic delay in the the planning and in following the initial roadmap
- Covid-restrictions affect the data collection and consequently the analysis.

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6. Norway local assessment

Reporting area 1: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships. The school and out-of-school interface.

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. The Local Assessment report shall provide insights on the challenges and opportunities that have emerged at the interface of the school and the out-of-school contexts.

Data sources to be considered include, but are not limited to: preparation and follow up meetings/workshops/interviews involving researchers and school leaders/teachers; between researchers and out-of-school actors in the network; between school leaders/teachers and out-of-school actors; participation of family members, etc.

Analytical concerns to be considered include, but are not limited to: co-design processes, change-lab workshops, institutional boundary crossing or lack thereof, practical/pragmatic coordination issues within and across institutions, access to data sources, …

Methods

Norwegian Local Network's Sub-networks

The analytical insights gained through the Norwegian local network's activities draw on a series of collaborations with different schools and actors that constitute specific sub-networks within the national local network. In this section, we present each of these sub-networks in broad strokes, as they constitute the overall empirical basis of the findings presented throughout the rest of the report. Specific data sources and participants drawn in our analysis will be further specificied under each reporting area and section.

Sub-network 1: Økern area collaboration

The Økern area collaboration sub-network revolves around an upper secondary school situated at Økern district, in Oslo, itself part of a city borough in very rapid development. Today, the city area represents an important neuralgic traffic node, and is largely built around business areas, with little green and social areas. But there is intense investment and development work taking place, and the municipality, along private actors, have set ambitions to transform the area in one of the greenest of Europe.

The SEAS Økern area collaboration begun with the ambition of connecting the school with the urban developments taking place around it. Partners in the network include a urban design firma (LEVA

Urban Design) operating in the area; Norway's biggest (in terms of members) environmental NGO, Fremtiden i Våre Hender (The Future in Our Hands); the cultural center Klimahuset (Oslo's Climate House), which is part of the Museum of Natural History, in addition to the upper secondary schoo, the University of Oslo (UiO), and cChange (the two later are core members of the Norwegian local network and are therefore included in all sub-networks).

The SEAS Økern area collaboration begun already in September 2019, as the SEAS project had just launched, and continues today. During this time, several projects have taken place, with varying degree of success and continuation potential. Main collaboration projects within this sub-network include:

- A collaboration with LEVA Urban Design in which students participated in local urban design decision making (September 2019 – June 2020)
- A 30-days cChallenge engaging nearly 120 students and 14 teachers
- A series of field trips and workshops co-organized with Klimahuset
- A natural sciences project called *Bending the Curve*, that focuses on climate change solutions, co-designed and implemented by teachers, researchers and out-of-school actors in collaboration. Groups of 3-4 students investigate a given solution (e.g., biogas in public transport) to address how to "bend the CO2 curve" of emissions. As part of an inquiry-based progression, the students explore the pros and cons of their chosen solution, conduct experiments, collect data from different sources, conduct interviews with out-of-school experts, participate in workshops with out-of-school providers, and make a collage of their ideal future that they present for teachers and external actors.

Whereas all of these activities constitute empirical background for the current report, the latter "Bending the Curve" project will be the main data source for the insights developed in this report from this particular sub-network.

Data sources include teachers' planning and debriefing meetings as well as change-lab workshops, interviews with teachers and students, observations and interviews during field trips, as well as student presentations and products.

Sub-network 2: Fredrikstad

The sub-network Fredrikstad revolves around an upper secondary school located in the city of the same name, a urban area South from Norway's capital. The growing sub-network includes, in addition to the upper secondary school, a local artistic and social entrepreneur organization called Håpets Katedral ("Hope Cathedral"), a local social entrepreneur company (Cube 8), several local circular-economy actors, local industry, as well as local and regional politicians. These in addition to cChange and the University of Oslo. The network is solidly anchored in the city's green business and public orientation towards sustainability issues and often engages the general public through media/TV outreach.

The SEAS collaboration in this network has involved a year-long (2020 – 2021) open schooling partnership focusing on a regional transformation toward circular economy in general, and the problem of plastics in particular. The year collaboration has developed into three interlaced and consecutive interdisciplinary project periods involving the same class/group of students/teachers:

- Hope in Plastic project, which involved the school collaborating with local artists, circular economy actors, and plastic reciclying industry, where the students contributed in the building of a "Cathedral of Hope" made from plastic collected from the sea and repurposed to be the colorfull roof of the cathedral building. The Cathedral of Hope is not only a building but also a multi-religious association dedicated to generating hope towards sustainability through social entrepreneurship. The project culminated with the organization of an art and science exhibition led by the students.

- Old Me New Me cChallenge, which was organized as a follow up to the Hope in Plastic project, and concominant with a parallel unit in which students, in groups, had to create their own political parties with their political programs. This concominance served as a means to connect experimental with change and transformation while connecting the personal, practical, and political dimensions.

- The Story of FredriksStuff, in which students are invited to select and investigate the life cycle of locally produced products, from the raw materials to their waste and/or recycling. The project involved getting out into the local industry and carrying interviews and research on local producers' practices, transport, economy, laboral conditions, as well as a range of socio-scientific dimensions.

Data sources include teachers' planning and debriefing meetings following the change-lab methodology; student and teachers interviews, in-class participation and observation, observations during field trips, student-led exhibition day with posters, films, scientific and miscellaneous stands, and student group presentations on local products in relation to questions of circular economy.

Subnetwork 3: "Learning to Think Like a Watershed"

This integrative subnetwork operates at three interrelated strata: 1) on the level of one school-specific, class-specific, transdisciplinary project ("The Salmon Project") with a designated time frame (early 2021 – November 2021); 2) on the level of co-designing an open-ended, periodical "Green Team" forum with that same school on the role of open schooling for transforming in-school culture while causing (in-school and out-of-school) "ripples of hope"; and 3) on the level of contributing to an annually returning, city-wide sustainability community gathering centred on Oslo's largest river and her population of migrating salmon, and the potentials and challenges therein to establish durable, periodically regenerative open schooling networks working towards narrative for change.

"*The Salmon Project*" / "*Ripples of Hope*" (led by a private international school in Oslo) includes as partners the international school (1 lead teacher, two support staff, students (n=approx. 30)), the University of Oslo, the City of Oslo (bureaucrats), local filmmaker and writer of several theme-specific

textbooks, Clean Coast Anglers (NGO), Akerselva Trebåtforening (NGO), Grønland Flytende Hage (NGO), Deichmanske Bibliotek Grünerløkka (local library as venue for outreach), VILLAKS (NGO), parents, the general public (as audience & readership), Frode Staldvik at Nasjonalt Villakssenter (NGO)

This ongoing project has been working with two aims: 1) to co-design the trans-disciplinary "Salmon Project" for 8th and 9th grade service-learning classes, with a focus on producing a student-led, inquiry-based documentary film centred on a local sustainability issue. Tasked with narrating the life cycle of the fish through one solar year, students themselves led the research, writing, filming, animating, music, editing, and ultimately screening and disseminating of their work; 2) to use the project phase (early 2021 – November 2021, involving some of the projects' students across the span of two school years) as a means to establish and explore more lasting, sustained open-schooling collaborations between the school and its local community through collaborating on the establishment of an inner-school "Green Team" or board of expertise integrating students, teachers, NGOs, parents, and researchers on questions of transformative sustainability work, centred on the practical design work called, by the school, "ripples of hope".

The MOTSTRØMS Villaksfestival ("Against the Current Wild Salmon Festival") is a locally embedded, annually returning cultural-ecological arena for open schooling initiatives working towards narratives for change. It involves a partnership between VILLAKS (NGO), local schools and a range of local actors, both public and private. This year's first articulation of the festival involved two local schools (Oslo International School (8th and 9th grade) & Lilleborg Skole (elementary level)). Both schools are considering renewing their commitment for the coming year. An additional school has approached us to explore possibilities for an open schooling partnership in the coming year (leading up to November 2022). Discussions are ongoing about establishing collaboration with further schools, with a principal geographical orientation toward schools inside the watershed, and with an intention of designing and implementing open schooling partnerships that are periodically regenerative and thereby will keep generating momentum over time.

Data Sources and Participants for Reporting Area 1

In our analyses for reporting area 1, on the interface of the school and the out-of-school, we draw from two main types of data sources: A survey on teachers' attitudes and experiences on interdisciplinary teaching, and video-recordings from interviews, meetings and workshops involving teachers and out-of-school partners in sub-networks 1 and 2.

Survey on teachers' attitudes and experienced challenges and opportunities of working in open schooling interdisciplinary teaching for sustainability.

An online questionnaire to survey upper secondary teachers' attitudes and experienced challenges and opportunities in interdisciplinary teaching for sustainability was created was created during Spring 2021 based on a review of the literature on teacher attitudes and concerns about teaching

sustainability in Norway[33]. The questionnaire was administered online, via invitation to schools participating in SEAS and extended networks. Invitations were sent to a total of seven different upper secondary schools located in different regions in Norway. Responses were anonymous and did not require participants to identify either themselves or the school they worked at.

27 reponses were included in the current analyses, although the survey is still running and we expect a larger number of responses to be recorded before the end of the year 2021. Responding teachers varied in years of experience, with 40,7% (n=11) having 5 or less years of experience, 7,4 (n=2) between 6 and 10 years of experience, 14,8% (n=4) between 11 and 15 years of teaching experience, and the remaining 37% (n=10) more than 15 years of experience. Responding teachers teach a number of different subjects (13 different subjects were identified as main subjects), most of them teaching at least in two subjects, with natural sciences (18,5%, n=5) and use of natural resources (18,5%, n=5) being most common as main teaching subject, and mathematics (n=3) and geography (n=3) being among the most frequent second subjects.

The questionnaire includes 19 items inquirying into teaching experience and background, perceived relation between subject and the interdisciplinary topic of sustainability, attitudes and understandings on the concept of sustainability, overall teaching methods, tools and resources used when teaching on sustainability issues, experienced challenges when teaching sustainability, particularly with regards to collaborating with external actors. It is this later aspect that we focus on in this section.

Interviews and Ethnographic Documentation of Planning and Debriefing Meetings and Workshops

To further enrich and interpret the insights gained through the questionnaire, we draw from video recordings of interviews, meetings, and workshops conducted as part of the collaborations in sub-networks 1 and 2. These two sub-networks offer an interesting contrast in the way and extent to

[33] Bjønness, B., & Sinnes, A. T. (2019). Hva hemmer og fremmer arbeidet med Utdanning for Bærekraftig Utvikling i videregående skole? [What does constrain and advance work in education for sustainability in upper secondary schools?] *Acta didactica Norge*, *13*(2), 4. https://doi.org/10.5617/adno.6474; Høigård, A. B. (2021). Bærekraftdidaktikk fra et lærerperspektiv. En kvalitativ studie av samfunnsfaglærers erfaringer med bærekraftdidaktikk. [Didactics of sustainability education from a teacher perspective. A qualitative study of social science teachers' experiences with education for sustainability]. Master thesis, University of Oslo; Larsen, A. (2020). *Bærekraftdidaktikk i fagfornyelsen—Samfunnsfaglæreres nøkkelaspekter for en «bærekraftig bærekraftdidaktikk»* [Didactics of sustainability education in the Norwegian educational reform—social sciences teachers key aspects for a sustainable didactics of sustainability]. Master thesis, University of Oslo. https://www.duo.uio.no/handle/10852/79759; Sundstrøm, E. M., Killengreen, S. T., Misund, S., & Köller, H.-G. (2019). Realisering av utdanning for bærekraftig utvikling (UBU) – slik erfart av et utvalg naturfagslærere i videregående skole [Realization of edudation for sustainable development–as experienced by a selection of natura sciences teachers in upper secondary schools]. *Nordic Studies in Science Education*, *15*(2), 206–222. https://doi.org/10.5617/nordina.6142;

which they have managed to engage external actors in their collaboration, and serve as a basis for a comparative study. Additionally, sub-network 2 offers a particularly successfull case of organically expanding relationship between the school and the local community that has served as a focus case for a longitudinal, in-depth approach. In addition to a succesfull organization of collaboration with the local community, the number of activities and groups of participants involved is better delimited and offers a more cohesive case for a case study (a full-year period with two group of students and a team of collaborating teachers, as compared to sub-network 1, which involves a much larger number of participating students (n≈320) and teachers (n≈16) who have changed roles and degree of collaboration/engagement through a 2-year period). The data sources drawn on in this area that are specific to sub-network 2 are detailed in table NO1.

TEACHER- and PARTNER-FOCUSED DATA FROM NORWEGIAN SUB-NETWORK 2 (Excludes all documentation of activities, interviews and workshops involving students' participation and their products)				
Project period	**Date (yyyy.mm.dd)**	**Data Type (data source)**	**Participants**	**Milestone/notes**
Establishment	2020.06.26	Meeting/Workshop (Online Video)	2 UiO researchers, 1 cChange representant, 2 School leadership representants, 1 teacher	Establishment of collaboration. Presentation of schools' plans, outline of research intentions.
	2020.08.05	Meeting/Workshop (Online Video)	1 UiO, 2 cChange, 2 School leadership, 1 teacher	Consolidation of collaboration. Planing of research collaboration and data collection.
Hope in Plastic	2020.08.19	Meeting/Workshop (Online Video)	1 UiO, 1 cChange, 1 School leadership	Concretizing collaboration with local actors and next practical steps in the project Hope in Plastic, which involves collaborating with a local organization building a Cathedral of Hope working with plastic collected from the ocean.
	2020.08.20	Interview (Video)	1 UiO, 1 school leader/teacher	Interview with English teacher, who also is member of leader team (coordinator)
	2020.08.25	Interview (Video)	1 UiO, 1 teacher	In-the-field interview with participating social studies and geoagraphy teacher during out-of-school activity
	2020.09.08	Meeting/Workshop (Online Video)	4 teachers (English; Norwegian; Natural Sciences; and Social studies and Geography) 1 cChange, 2 UiO	Change-lab meeting including reflection on experiences so far, and planning of further pedagogical activity
	2020.10.15	Interviews (Video)	3 participating teachers, 2 out-of-school partners (1 local politician and 1 local actor representant)	In-the-field interviews during public exhibition organized as part of the Hope in Plastic project
	2020.11.03	Meeting/Workshop (Online Video)	4 teachers (English; Norwegian; Natural Sciences; and Social	Change-lab meeting reflecting on the Hope in Plastic project as a whole, after it has been

			studies and Geography) 1 cChange, 2 UiO	concluded. Planning of further pedagogical activity
Old Me New Me	2020.11.10	Meeting/Workshop (Online Video)	7 teachers, 1 school leader, 2 cChange, 1 UiO	Meeting to discuss and prepare implementation of 30-days cChallenge; planning activities and data collection.
	2020.11.17	Meeting/Workshop (Online Video)	cChange presentation	Introduction for participating students (2 classooms) and teachers (n=8) of cChallenge's principles and procedures
	2020.12.01	Meeting/Workshop (Online Video)	5 teachers, 1 cChange, 2 UiO	Change-lab meeting reflecting on the Old Me New Me cChallenge, which is ongoing at the time. Planning of further pedagogical activity.
	2021.01.15	Meeting/Workshop (Online Video)	4 teachers (English; Norwegian; Natural Sciences; and Social studies and Geography) 1 cChange, 2 UiO	Change-lab meeting reflecting on the Old Me New Me 30-days cChallenge, which has recently finished. Planning of further pedagogical activity.
The Story of Stuff	2021.02.12	Meeting/Workshop	4 teachers (English; Norwegian; Natural Sciences; and Social Studies and Geography), 1 cChange, 2 UiO	Meeting to collaboratively plan the about-to-start project "The Story of Stuff", which involves researching the life cycle of a self-chosen product locally produced.
	2021.05.18	Meeting/Workshop	2 teachers (Natural Sciences; and Social Studies and Geography), 2 UiO	Change-lab meeting reflecting on the Story of Stuff project, which has recently finished. Planning of further activities, towards conclusion of year collaboration.
Concluding Year	2021.06.16	Meeting/Workshop	3 teachers (English, Natural Sciences; and Social Studies and Geography)	Change Lab meeting in occasion of politician visit to school that was motivated by the SEAS collaboration. Final reflections of the year and envisioning future collaboration.
	2021.08.nn	Meeting/Workshop	2 teachers (Natural Sciences; and Social Studies and Geography), 2 UiO	Meeting to follow up threads from previous meeting and to plan further collaboration for the 2022-2023 period.

Table NO1: Teacher and local partner-focused data sources from sub-network 2.

2.1.2 Analytical procedure and approach

Overall analytical approach for the local assessment

As it was the case in the first SEAS local assessment (Deliverable D3.1), our overall research design for the present reporting is based on a case study methodology, which is a type of inquiry that "investigates a contemporary phenomenon in depth and within its real-life context" (Yin, 2009 p. 18). We use a case-based approach within a broader cultural-historical theory framework (Engeström, 2001; Roth & Jornet, 2017), which takes as point of departure the idea that object-orientedness—the

way in which goals emerge and are pursued in and through socio-material practices—is fundamental to understanding human activities.

Setting object-oriented activity as our general unit of analysis orients our analytical attention to the way that participants develop socio-material practices over time in a dialectical move between a shifting object of activity (that motivates the collective acitivity) and individuals' establishment and netogiation of goal-oriented actions through given tools and concepts. The latter are established and negotiated within emerging and evolving *communities of practice* (Lave & Wenger, 1991), which are groups of people with shared concerns or interests and who develop cultural means to maintain the community's cohesion and identity as community. This is a revealing approach to studying how partners from different backgrounds—the school, the out of school—come together and collaborate towards joint goals of transforming and improving education for sustainability and their local communities through open schooling.

Specifically, cultural-historical activity theory directs our attention to the dialectical, mutually constitutive relationship between a community of practice's constitutive elements, which include the subjects (persons) as they relate to their emerging object of activitiy (historical collective motives, personal goals) through development of given social norms and rules, division of labor, and the cultural tools that are developed or deployed to organize the labor, including concepts and narratives as well as material objects. Moreover, the analytical attention is on the genetic, developmental dimensions, not only on cross-sectional and/or factor-like aspects. This involves an interest in how socio-cultural practices (of open schooling, in this case), are produced, re-produced, and transformed through actual social material practices as motives and goals also transform.

Analytical procedure for reporting area 1

Questionnaire responses were exported as a tabulated text file from the online surveying application used to collect responses (nettskjema, created by the University of Olso) into the statistical analysis package SPSS. Simple descriptive analyses were conducted to display frequencies per item.

Questionnaire results were further framed and interpreted in light of additional qualitative data collected through interviews and ethnographic observations working with teachers in the field across the different open schooling sub-networks presented above. Video and/or audio recordings of interviews, meetings and workshops were transcribed and annotated using video-annotation software (Inqscribe, Atlas.ti). Emerging themes were categorized following thematic analysis principles and tecniques (Braun & Clarke, 2006). These themes then were further contrasted across the two source cases for the reporting area (sub-network 1 and sub-network 2), and followed up as they unfold genetically through the respective networks' development, with a focus on how emerging cultural tools and motives related to the school – out-of-school collaboration.

2.2 Findings

In general, teachers appreciate and consider working with external actors an important but underexplored/underused asset to foster education towards sustainability.

Given a variety of options, including having access to ready-made teaching lessons, teachers perceive as most desirable the options of (i) having teaching units that include the visit of or visit to external actors (85,2%) and (ii) having the opportunity to organize open schooling units in which students' get opportunities for authentic learning in real settings outside the school (81,5%). Collaborating with external actors as part of open schooling-like initiatives is, therefore, perceived as an important asset to foster education for sustainability.

However, the prevalence of these collaborations seems to be lower than desired, with teachers wanting more of those collaborations than what they experience today. For well over half of the respondents (63%), out-of-school activities such as participaitng in guided excursions or externally offered courses happen „sometimes" as part of their teaching for sustainability, and for a 30% these are „never" part of their teaching for sustainability. 66% of respondents agree or totally agree with the statement „extnernal actors should be involved in interdisciplinary teaching on sustinaiblity to a greater extent"; with only 11% being in disagreement with this statement. These numbers are exactly the same when it comes to including externally driven visits or lectures taking place in the school premises.

Teachers perceive a wide range of external partners as relevant and attractive to collaborate with in open schooling initiatives.

Generally, teachers appreciate a variety of external actors as relevant to collaborate with, without clear preferences as to a particular kind of actor. Given the opportunity to choose between collaborating with local businesses, NGOs, public institutions external to the school, or academy and research, there seems to be slight preference for the two first choices (88,9% and 81,5% respectively), but the later two seem to be seen quite positively as well (with 70,4% of respondents considering them possible relevant partners in each case). Visits of youth rolemodels and individuals with relevant life experiences connected to issues of sustainability were mentioned by several as attractive options in additions to the ones mentioned above.

This open attitude towards collaborating with multiple types of external actors is further substantiated in the diversity of collaborators that charecterize the different sub-networks within the Norwegian local network (see pre-amble to Methods section above). As reported above, the participating schools in the Norwegian local network collaborate with a wide arrange of partners, from NGOs and cultural centers to small business. The opportunity to further examine whether different kinds of partners offer different types of support and resources for education towards sustainability exists in the current network and future research could be conducted that elucidates this question.

Time and resources as main hindrances to, but also as division of labor opportunities that come with collaborating with external actors

Asked about what they experience as most challenging when it comes to involing or collaborating with external actors, respondents point at limited time for organizing the collaboration (85'2% of respondents), along with limited economic/labor resources (66,7%) to do so. When given the

opportunity, in the questionnaire, to further elaborate, several of the respondents comment on the additional difficulties that the COVID pandemic has brought to bear during the past couple of years.

The importance of having time available for making open schooling collaboration possible has also been raised during the teacher interviews as one critical aspect, where one teacher collaborating in the sub-network 1 emphasized getting support from the external collaobrators to get things done, given time and energy constrains in her everyday work. Delegating or rather distributing the work among teachers and external partners—such that external partners execute aspects of the teachers' work—has been positive for teachers as a means to free up their time—rather than becoming an additional load—and make it possible to engage in more innovative work. Here, the issue of available time and resources becomes not just a potential hindrance, but also and at the same time, and opportunity through open schooling collaborations.

Interstingly, this same informant connects the challenge of time with an issue of having vital energy to meaningfully contribute—an issue that often emerges in conversations with teachers in open schooling collaborations and which has to do with *work sustainability*, the issue of making sustainable the work of teaching for sustainability (which we discuss under reporting area 3). But the issue of time is brought up also in its counterpart form, that is, *not as a limitation but as an opportunity* that emerges through the collaboration. This connects with open schooling collaborationsn as means to allow for new distributions of labour (time and resources), where external actors can contribute amilioreting the situation through shared labour.

Discussing the importance of finding a balance in the division of labor with external partners, this teacher emphasizes how she might have wanted to contribute more in the collaboration but having felt unable to do so:

> «…I have some times [during the collaboration] thought that I have myself participated little in contributing ideas and activities and that kind of thing, and I notice it has with my workload to do, that there is a lot to do and one really wants to get a good project, but the overhead needed to really set oneself on it and be actively involved in coming with lots of ideas, that energy or overhead has not been there."

For this teacher, delegating part of her responsibility onto external partners (in this case, a private company focused on facilitating change processes and the university), who have been active in the sketching of possible activities to implement in the teaching unit, has been a useful resource.

Division of labor between school leaders and teachers as crucial for managing relationships with external actors and making open schooling sustainable

Division of labor to make collaborations sustainable emerges as an issue not only across the school and the out of school partners, but also among school leaders and teachers in managing the relationships with the external partners. This is made clear by a teacher and member of the school leadership in sub-network 2—which has been particularly successful in establishing a solid and growing local open schooling collaboration network—who during an interview (2020.08.20)

emphasizes how important it is that the task and responsibility of keeping coordination with the out-of-school partners is on the leadership group and not the teachers. She emphasizes this while appealing to the importance of "making it sustainable for the teachers"—an issue that will feature prominently in our analyses presented in reporting area 3.

This informant's remarks are further corrobareted by the collaborating teachers later during meeting and workshops, where the decision to delegate the responsibility of establishing, exploring and maintaining the conections and coordination with local external actors on a member of the leadership—rather than on the servicing teachers who have to deal with lesson and activity planning and implemention—has been praised in several occasions.

In our observations across different sub-networks, the notion seems important, but—as expected—there is no one single recipe. In sub-network 1, the coordination with external actors was also not falling on to the teachers, but was managed by a third external partner, cChange, which coordinates the Norwegian local network. Yet, collaboration with external partners such as the urban design partner has not flourished, resulting in a relevant and interesting, but less successful story of collaboration. But in a more recent open schooling collaboration (not included in this rapport), we (UiO) are also managing the coordination with external partners, having so far been (more) successful (than on sub-network 1). This suggests that the effect of distributing labor for coordination with external partners is mediated by other aspects, some of which may include perceived value of the collaboration, as discussed below.

Establishing common goals and values as vital: economic and principled views of "value"

The need to facilitate work to establish common goals across the collaborating partners in open schooling networks is embedded in the SEAS Change-lab methodology (see deliverable D2.4), and the finding reported here is simply a corroboration of the premise in our approach. Yet, it is still relevant to report on it as it has been emphasized by informants in all of the sub-networks, particularly as it relates to the issue of value: both values as in principled values, but also as in exchange value.

The importance of being intentional about establishing common goals and interests has been made plain both through our facilitation practices, but also by the participants themselves. While there is no single recipe to achieve the goal of establishing common goals in a way that is conducive to sustained and productive collaboration, in our observations, considering how participants frame the issue of values has become important. Specifically, we have observed two different ways of framing the issue of values: an economic and a principled or normative way.

The economic approach to value has been observed when external actors and/or school members orient their assessment of the ongoing collaboration with respect to gains and exchange values between partners. We have observed this orientation particularly in sub-network 1, where questioning the value of the open schooling collaboration has been raised both with respect to collaborating with local businesses (a urban design company) and with the researchers team at UiO. With respect to the later, one teacher, reflecting on the development of our collaboration during an

interview, states that for her was important to know that „…it is not just about being researcherd, but that we get something in return" (an issue that was raised in the context of division of labor already discussed above, where the researchers and external partner cChange were developing specific teaching materials). In the context of a collaboration in which the co-researching role of the participants and the aim to together develop knowledge about open schooling has been emphasized in multiple workshops, this statement is symptomatic of the fact that stating collaboration intentions is not enough: these intentions need to materialize in specific forms of engagement and collaboration, which are assessed according to current world views. For this teacher, the value of generating knowledge was not in developing understandings, but in actually and in praxis, experiencing some distribution of labor in the development of specific teaching mateirals and methods (not just in theory).

Similarly, an economic view of value was expressed by teachers in the same school when referring to another external actor, where the teachers complained that they could not see "what's in it for them? What's in it for the students?" when the students where recruited to participate in workshops that included hands-on labor to build up public spaces in their local neighborhood. Despite several workshops in which shared goals of experience-based education and open schooling as a way of engaging students with community issues, questions of value were mostly framed in terms of exchange, of giving and getting—in this case, learning goals and learning skills, career oppurtunities, teaching activities—rather than of collectively contributing to greater goals.

This economic view contrasts with a consideration of the common values as normative, independently of individual gains or exchanges in the collaboration. We observe this orientation unfolding in sub-network 1 after a longer relationship and deeper work to build common orientations towards pedagogical goals have been worked out, which suggests that underlying it is a deeper understanding of open schooling as a collective goal and the development of trust. But also and most clearly we observe this orientation as domintating in relationships in sub-context 2 from the start. In the later case, an orientation to practical activities that in principle seem to have little to do with specific learning competences, such as picking up and cleaning discarded plastic and help building up a roof, was not questioned. The "additional" educational value was assumed and explored futher, an exploration that did not unfold in the case of sub-network 1, possibly, as mentioned, because taking that "risk" involves both a normative re-orientation but also trust.

Perceived and enacted values in open schooling collaborations

While the quantitative survey clearly documented the positive orientations to and desire to engage in open schooling collaborations with external actors, a more nuanced understanding of why and how teachers see value in these collaborations emerged from the analyses of interviews and collaboration meetings and workshops. Here we list some of those observed values:

- *Teaching that is experienced as more relevant and authentic.* If there is one recurring theme that teachers discuss when they are asked or spontaneously reflect upon the value of their open schooling collaborations, that is the observation that collaborating with external actors

offers them opportunities to offer the students more engaging and authentic learning activities. Collaborating with exernal actors offer opportunities to bridge otherwise disconnected realms of life: school and the rest of life. As one teacher in sub-network 2 poses it, "we train and we train and train but we never arrive to the real match; what happens is an articifical arena".

Particularly valued by the teachers have been opportunities for students to present their work in public arenas and for real audiences. This has been emphasized by virtually all participating teachers. A Norwegian language teacher went as far as to say that "the biggest challenge for me (teachin Norwegian) is that students prepare texts for the teacher, not for real audiences. It is not everyday we get our students to craft texts and materials for real audiences".

- *A means to decentering and challenging traditional ways of teaching*. The idea that open schooling serves as a means to develop into more progressive forms of teaching is also emphasized. Collaborating with external actors forces school educators to change their views, habits and expectations of what it means to be a teacher. One teacher describes it in the following way: "…it challenges us to go one step further, because we can no longer simply 'own' the learning"

- *A means to facilitate development of agency*. An important value in SEAS has to do with the educational goal of empowering learnings to become agents of change in a changing society, and this is a value shared by all sub-networks. Those who have worked with these ideas longer are the ones who most appreciate the opportunity to engage in open schooling as an opportunity to let students experience that they can make a difference through their learning and education.

Not just shared goals, but also shared objects and communication channels

The importance of establishing shared material objects in complex interdisciplinary collaborations is not new (e.g., Star & Greisemer, 1987) and was reported in our prior annual local assessment. This has been again emphasized and observed, where teachers have remarked that establishing shared communication channels and documents that could be co-edited and followed up by multiple partners has greatly enhanced the collaboration: "It's been very nice that we have had the shared documents, that we can see point per point what we are going to do, the steps in the process; we have had a channel or documents where we can see it". In the different networks and projects we have observed multiple digital tools, including Miro, Teams, Google Docs and other. An analysis of the affordances and constrains of each of these tools for different types of projects/collabarations is beyond the scope of this report but would be an interest area of further reseach.

Conceptual model(s)

An important conceptual model that derives from and/or can be seen as relevant to the findings reported above can take as starting point the Cultural-Historical Activity Theory notion of object-oriented activity, which often is represented in the form of a triangle, as in the figure below.

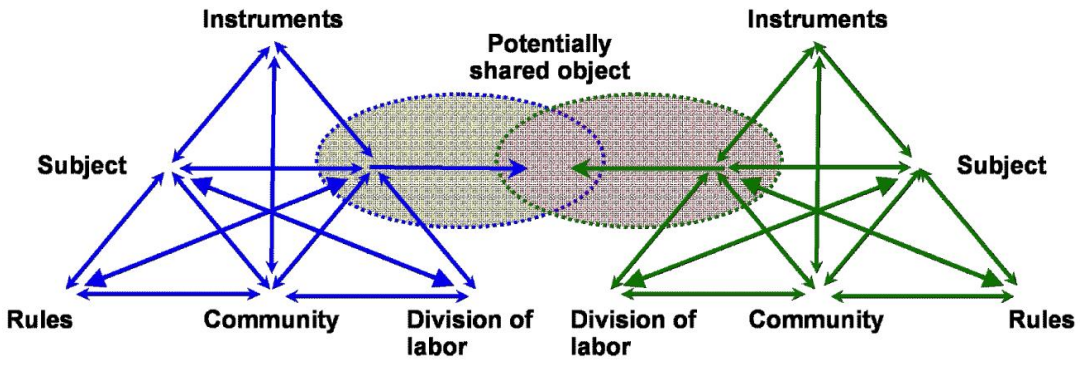

Figure NO1: Activity systems interacting

The figure shows the inner general structure of activity systems (comprising instruments, subjects, rules, community, and division of labor, all of which mediate the development of objects of activity) as well as the challenge of two systems relating to a potentially shared object and thereby transforming themselves (Engeström & Sannino, 2021).

In the analyses presented above, we see how our work can potentially specify types of object-oriented relationships and dynamics that emerge in open schooling collaborations. Specifically, the notion of educational value in open schooling and how different understandings therefore may lead to different rules and conceptualizations of the shared object are interesting to pursue. The idea that traditional education can lead to economic and capitalistic understandings of learning and education has been advanced and problematized (Lave & McDermott, 2002; Williams, 2011). How transitions into open schooling forms of education—that is, forms of education in which the normative value relates to the achievement of the common good rather than of "learning" or the acquisition of skills per sé—may be mediated by explicit efforts to challenging traditional (explicit or implicit) views and habits of teaching and learning relationships as primarily drive by exchange value principles is an exciting research arena and prospect to build a conceptual model of open schooling collaborations.

In the same vein, the empirical materials reported here offer a solid ground to explore the possibility of building up a conceptual model that represents core organizational features in the division of labor within and across school and out-of-school partners in open schooling collaborations, including differentiation of coordination tasks among teachers, school leaders, and external actors and researchers. The comparative analyses contrasting the different sub-networks offer that potential, which can be further realized in the materialization of WP5 deliverables.

Updating and differentiating SEAS concepts, tools, and methods

The findings reported above have important implications for the SEAS Change Lab methodology, as presented in D2.4, and for some aspects of the LORET tool.

With regards to the Change Lab methodology, the observations reported above suggest the need to reconsider embedding an analysis and explicit consideration, in the collaboration workshops, of the implicit approaches to normative values in education towards sustainability, and open schooling more generally. While the notion of facilitating the establishing of shared goals and building trusts are on place and clearly stated in the methodology, the current findings provide further nuancing as to how such overall strategies may be pursued in practice. As SEAS moves on generating empirical materials to build upon, it becomes possible to integrate the following in the methodology to facilitate workshops: (a) a list of documented values and goals in prior and ongoing open schooling collaborations, so that (b) explicit discussion of these and of the broader ways in which we frame values (for example, normative vs economical framings) and how these reflect our expectations in the collaboration.

With regards to LORET, the findings reported in this area point towards the relevance of considering the organizational conditions that allow a team of teachers to sustain collaboration with external partners in a meaningful and practically feasible, sustainable manner (this topic is further developed in reporting area 3). As we read it today, although LORET emphasizes the need to tailor the tool to the specific organization being involved, it does not in itself address these organizational and coordination issues directly and instead focuses on the achieving locally relevant teaching plans. While these plans—and the steps the LORET tool prescribes—have proved crucial in our work (see the section on shared objects above, and further below in reporting area 3), there may be need to better contextualize the tool so as to address the orgainzational, structural issues (including normative rules and division of labor) that are not taken up in LORET. One solution to this, which is taken in SEAS, is embedding LORET as a tool within the ChangeLab methodology. But we know by experience that, in praxis, there is not time to do LORET AND ChangeLab workshops but both need to be somehow integrated. This note is to call for such an integration or for en expansion of the tool to be more relevant to those organizational issues that surround the possibility of actually writing down a meaningful, locally relevant teaching plan.

Identifying Dilemmas

The issue of educational values in open schooling and in educational for sustainability more generally relates to an issue raised with regards to two conflicting concerns: "a concern about the instrumentalisation of education, and a concern for the urgent need of widespread engagement and mobilisation for coping with the consequences of severe socio-ecological problems" (van Poeck & Östman, 2020, p. 1003). This particular issue emerges in the cases described above as an issue, where teachers may perceive that engaging in practical activities oriented towards achieving practical goals outside of the school (i.e., actually addressing the authentic sustainability challenges

that teachers emphasize as indeed valuable) is not "fair" if something is not given back to students or schools in their learning task. This is of course a fair concern. Yet, our analyses suggest that this concern depends upon deeper assumptions of value and what education is for, as well as to practical socio-material organizations, where sub-network 2 seemed to have been able to see educational value where sub-network 1 may have not yet seen it. This is an important are of debate that the current findings can contribute elucidating.

Another dilemma concerns the establishment of open schooling network-structures resilient enough to endure such stressors as 1) the dropping out of individual project enthusiasts, 2) the lack of time, 3) the lack of funding, and/or 3) an insufficiently supportive school culture which would help carry such structures across and through emergent bottlenecks. The findings reported here suggest this to be a structural or design dilemma. The findings reported here and forther below in repor area 2 further suggest that the dilemma can be transformed into opportunity, in part, through embedding concrete open schooling practices within larger, recurrent, commuity-oriented initiatives with an inbuilt design towards self-transformation. Examples of such recurring structures are presented in area 2 (see Study 3), where an analysis of the transformational potential of the sub-network 3 is presented.

"Resilience" and "networks" are central concepts in systems theory, alongside other potentially relevant concepts for analysis such as "interdependence", "cycles", "diversity", "nested systems", "flows", "development" or "dynamic balance" (Capra, 2005). The implication here is that a systems theory-approach to analysing the dilemma is relevant. In the case of open schooling for action and engagement toward sustainability, this implies an analytical turn toward the discourse on ecolological literacy, or ecoliteracy, as itself an articulation of systems thinking for, and with, education (Barlow & Stone, 2005).

Reporting area 2, Norway: Challenges and opportunities to transformational engagement, scientific literacies, and motivation

One of the main premises in the SEAS project concerns the idea that, in order to address the important challenges of sustainability that we are facing, education needs to revise the ways in which scientific knowledge is understood and delivered in education, so as to become actionable and meaningful in real life contexts. As elaborated in the SEAS project description, a long tradition of socioscientific issues in education has shown how, when students engage in addressing real, complex problems, knowledge on scientific issues needs to be expanded so as to include personal as well as political dimensions. Local assessment in this area aims to document the forms of scientific literacies that emerge (factually or potentially) through open schooling collaboration, and how these relate to the participants' motivation for and agency towards knowledgeably addressing real life problems of sustainability. It also involves possible assessments on ways in which open schooling innovations present new or particular challenges to more traditional forms of teaching.

Data sources to be considered include but are not limited to questionnaire (including SEAS Global Assessment Instrument, GAI), interviews, and ethnographic observations of learning trajectories across contexts.

Methods

Data sources, participants, analytical procedure and approach

We document reporting area 2 by means of three different case studies, each one drawing on different data sources and analytical approaches, but all three addressing core issues relating to narratives of change and transformation.

The first study draws from sub-network 1, in particular from the project „Bending the Curve" described above. Data sources consist of products from the students' activities, including collages, PowerPoint presentations and audio recordings thereof, group interviews with the students and teachers, and video recordings of the planning and reflecting meetings. Other available data sources include recordings from Zoom-meetings of Teachers co-creating a lesson plan for a science class and observations from students' presentations and visits in their local environments and field notes from these. Prior to the co-creation of the lesson plan, actors in the local community and some students discussed their insights on the themes of the lesson plan with researchers.

In this study, thematic and discourse analyses are conducted to examine students' narratives on their own agency with regards to sustainability issues. We further examine how learners construct *languages of possibility* that lead to integrative narratives, where the students' visions of the future are better integrated with critical thinking about practical, social, economic, political and scientific issues. Special focus is given to how concepts from different domains (personal, science) are integrated in personally meaningful ways, and how this integration relates to agency towards sustainability. An important aspect of this case study is a critical analysis of how stories on imagined futures are co-created, and how the stories communicate possibilities for agency, action and actualizing our values.

Interviews are transcribed and a thematic analysis is conducted to recognize relevant themes in the observational data considering the research question. Discourse analysis is conducted to analyze some chosen episodes in the observational data that illustrate the themes. A narrative analysis is conducted to analyze student' narratives of their agency related to sustainability. These narratives are both derived from students' testing of hypothetical thinking in their project and meaning making in conversations between students', teachers and researchers. The data analysis focuses on how learners develop languages of possibility, where the imagined development for sustainability is combined with critical thinking of practical, social, economic, political and scientific issues.

The second study draws from sub-network 2, more specifically from the cChallenge activity (Old Me New Me) that is described above, and explores issues of inter-textuality and transformation. The study examines the students' posts using a socio-linguistic approach that is described in more detail in the findings section.

The third study draws from sub-network 3, drawing from the full plethora of ethnographic materials collected, and considers narratives for change to be a central concern and promise. The case looks to establishing and coordinating open schooling partnerships that both envision and perform narratives for change. The case is therefore not only relevant to reporting area 2 on transformational engagement and motivation, but also for research area 1 explored above. A working hypothesis is that focusing on the level of changing narratives itself holds transformative potential. Philosopher Neil Evernden has argued that narratives can be a liberating force. Evernden writes in *The Natural* Alien: "Man's freedom lies primarily in the choosing of his 'story', rather than his actions within that story." (1985, 132) A crucial perspective here becomes to explore *what* narratives there are to choose between in the first place, that is, to explore the very possibility of a multitude of narratives, and thereby a multitude of possible responses to the climate and biodiversity crises. This comes against the background of documented, widespread anxiety, grief, and indeed despair amongst young generations in the face of these crises (Marks et al, 2021).

Findings

Study 1: Examining students' languages of possibilities in open schooling.

The study takes as point of departure the realization that one of the major impediments to action for sustainability is lack of (facilitating and organizing) positive visions for alternative futures. Drawing from analyses of student products and interviews conducted as part of the "Bending the Curve" project (sub-network 1), the present study investigates the following questions: *How *do* upper secondary students in science education take part in languages of possibility when working on and reflecting upon the present and the future during an inquiry-based project on climate change solutions?*

To empower students for cooperation in their local communities students might need to develop skills of integrating discourses and overcome contradictions between them. To facilitate the connecting of diverse discourses in a change process, there is a need to develop the kind of languages, which enable the thinking and communicating of possibilities aimed to develop more sustainable human-environment relationships. Giroux (1997) suggests that "a language of possibility" can increase our courage to envision an appealing future and systematically and critically work for the envisioned future. Based on studies on language use in science education (Roth, 2014), the current study suggests that languages of possibility are many and they change in social interactions.

In the context of the study on students' work towards imagining futures, students often struggle to connect the actions to take better care of their environment to structures that enable this kind of care. There seems to be a close connection between allowing oneself to care and experiencing that it is possible to act for what one cares about in practice. Students have learned varied narratives regarding their agency in sustainability through social media, their studies in school and other contexts and compare a narrative of an exceptional individual with a great impact to their own imagined and often limited possibilities to have agency. Many students place agency on individual's

consumer and behaviour habits, although they also acknowledge the importance of political and other structures that enable them to create and sustain sustainable habits.

Many students report that they found the project "bending the curve" as engaging and interesting. They enjoyed being able to "make their future better", study and think around one specific intervention in a deeper level and learn new knowledge about the intervention. This was experienced as uncommon since normally the students "do not think that much what they are doing". Normally they "talk about sustainability in general", aim to "finish the task", "try to do it as right as possible" and "get as good characters as possible". The students had divergent opinions on whether the project facilitated greater engagement towards sustainability or not.

Many students express their care about issues considering sustainability when they connect things, they already care for to specific sustainability challenges. When presenting their findings from the inquiry-process or when interviewed, if the discussed matter is personally meaningful for the students and touches issues they already care for, students seem to connect several types of discourses, such as practical, personal and political discourses. Students seemed to take ownership of their theorizing highlighting the word "our" in when referring to "our theory", "testing our theory" or talked about "our hypothesis". Most of the hypothesis students tested with an experimentation, were derived from questions arising in their inquiries. Students who studied the sustainability/circulation of clothes describe that they "went further with the question", aimed to answer, "why and how to use certain clothes", and they concluded that there is a need to take better care for the clothes a longer time and asked the question: which textile has the longest durability? Here the students questioned their everyday practices and ended up with a question of textiles physical qualities, which impact the durability of clothes.

It was experienced as surprising that at some point of their inquiry, grown-ups knew less about issues in question than the students, such as workers in the local shop, who did not know the answers to students' questions on the use/circulation of plastic. This made the students conclude that the workers should be informed about knowledge the students had acquired. One student said: "through informing several people we can acquire a better future".

Although many students commented that they found the lesson plan and the inquiry-based learning method motivating and engaging, for some students starting with an unspecified theme such as «reducing the use of plastic» was challenging. This might be because they generally struggle with tasks that require independent work with a general theme. Some students wished for more support, such as suggestions for ways to proceed in the inquiry process.

Students can reflect many complexities in agency for sustainability, such as how supply chains function in unsustainable ways and the fact that when the production locates in the other side of the world, the shipping of the products becomes unsustainable. In addition to larger problems, students are engaged to discuss practical contexts closely connected to their own lives, such as consumer habits. They speculate how change in people's consumer habits or prices in products depend on supply and demand relations. However, students seem to have a need to further integrate separate discourses to be able to make better sense of complexities in (their) agency.

Political aspects are discussed mainly in terms of politicians having the power to decide on issues concerning sustainability. Students' own political agency is mainly discussed in the context of voting, participating in demonstrations or expressing opinions through e-mail or social media. Although the students seem to connect sociocultural issues to biophysical questions when explaining the causes and consequences of different types of political decisions, the issue of being able to build effective integrative arguments based on both biophysical facts and sociocultural concerns remains to be more directly addressed in the context of political agency. It seems that if the students connect their existing concerns to the socioscientific discussion, they can acquire languages, which help them to expand in their understandings. Approaching the scientific facts through integrative arguments empathizes simultaneously with political and personal motives and scientific facts and decreases tensions between these.

This study provides input for implications on how to develop the learning about agency in sustainability in the educational context. Students vary in their level of independence when they work with a less specific task, such as in the current project.

Although students do connect their own education to possibilities to have agency both in their current and future lives, they rarely reflect how the different kind of knowledge they have learned enables them to have agency in sustainability. The more concrete decisions of buying less new and/or unsustainable clothes or becoming a vegetarian are easy for them to understand as sustainable choices, but only few students suggest ways that their living environment should be changed to enable them to make these choices. There were some exceptions though. When the students acquired more practical or theoretical knowledge than grown-ups around them, one student group concluded that grown-ups should be informed about this knowledge. This gives implications to empowering students to practice the role of an expert who can contribute to the local environment, including political discourse, and develop it further. As a conclusion, young people who seek ways to have agency in sustainability rely on learning about how they can have concrete possibilities to agency, participate in developing new opportunities and then being able to practice their agency.

Often when students describe unsustainable developments they refer to people as "them" and rarely position themselves as active agents who (unwillingly) participate in, which they describe as, negative developments. According to the interviewed students, agency belongs to individuals with power or money. Students experience lack of agency although many students mention that they can have power through social media, sending e-mail to politicians or participating to demonstrations.

When students discuss developments in sustainability issues such as the destroying of rainforests or plastic pollution in the sea and the researchers ask about how makes them feel, the students express surprise and confusion. Some students laugh as their first response, some take time to search for words, some answer first that they do not have any specific feelings towards sustainability issues. However, all interviewed students did express that they do care about nature being destroyed, plastic pollution spreading in seas and into living beings and the consequences of CO_2 levels rising.

The students tend to suppose that the interviewers are asking about what all young people think and feel. Students do not seem to suppose that their thoughts and feelings are in the focus of interest. Students seem to contradict the position of representing the young generation or "everybody else" and their personal feelings and attitudes. In the conversation with the one or two researchers, they are uncertain if their personal feelings and attitudes are really being asked about.

The study suggests that languages of possibility can develop when students discuss their possibilities to act for sustainability in their local communities and connect what they care about to the discussion. Connecting what the students care about to sustainability issues can enable their meaningful engagement and finding a personally relevant role as part of collective agency. In addition, this study proposes that languages of possibility develop when students are encouraged and concretely supported to create alternative interpretations, explanations and expectations on issues that connect to collective agency.

Study 2: Multiple voices and transformation in narratives of change and cChallenge

Rationale

Open schooling as conceived in SEAS aims for students to learn through becoming agents in social action. This requires students as future citizens to be allowed to explore sustainability issues that matters in the complexity of real-life settings, and through their actions and encounters across different settings, practices and institutional framings to gain insights, or simply, to learn. For the inclusion of school subjects, such as social and physical science, such open schooling teaching processes represents a challenge as school practices and knowledge domains need to be adjusted, transformed and negotiated, for students to find them relevant and useful for the concerns at hand. This section presents an early, emergent model of narratives of change that attempts to capture how students' encounters with places, events, texts and people take a role in their narratives. This work thus aims to theorize how a learning trajectory can be conceived, analyzed and assessed by way of a intertextuality as a theoretical lens as well as tool in practical analysis.

Analytical approach and background in D2.2

People "figure out" who they are and envision plausible futures for themselves and their surroundings through making use of cultural resources in social relationships with the people who take part in these same events. In such environments, new ways of being in the world can emerge in and through narratives. Narrative is the most fundamental pattern of sensemaking, as, in its most basic form, represents an ordering of experience that unfolds through time. Learning trajectories is in D2.2 (p. 10) conceptualized as "a "*meaning-making*" trajectory that shapes and is shaped as learners participate and engage in "*socio-scientific issues*" in diverse settings during their everyday life". If such narratives enable, describe and reflect on change as conceptualized in SEAS, they may be held as *narratives of change* (Cf. D2.2 section 3.1.2). If these narratives of change includes students' engagement with science (knowledge, methods, mode of inquiry) in its many shapes, often entangled with other modes of knowing and inquiry, such narratives of change are also evidences of scientific literacy, when they relates to "individuals and communities to "*meaningfully*" engage and

define sustainability issues, drawing upon scientific knowledge, yet not being in their engagement with the issues determined by it while engaging with the issues at hand (D2.2 p.18). […] Scientific literacy entails the ability to productively, yet also critically and reflexively, one engages with different forms of knowledge and traditions of practice. (D2.2 p. 20)). An important insight, and a source of dilemma for science teachers, is that inquiry on complex sustainability concerns, involving social action and democratic participation, requires a broader sense of inquiry besides the aims typically associated with (natural) scientific method.

The empirical analysis described below aims, for the purposes of D3.2, to contribute to the above mentioned concepts of SEAS, and may lead to a conceptual/methodological framework for identifying, reflecting on, and supporting the development of qualities pertinent to narratives of change.

In open schooling, described in D2.2 (p. 7) as involving "reaching out not just to make school accessible, but also to make it relevant to other spheres beyond formal education," investigating how narratives emerge and evolve can showcase how this process takes place in students' meaning-making processes and becomes relevant to out of school sphere. This dimension of openness, thus, has to do with connecting school activity with activities out-of-the-school; that is, connecting learning across formal, informal, and non-formal settings Thus, an essential learning experience is the encounter with places, institutions, ideas, ways of knowing, texts, tools, values and purposes. Narratives have the potential to transform such encounters into meaning and eventually, learning. We will analyze these interrelations through the concept of intertextuality.

Figure 1 in the project description of SEAS visualizes a relationship between arenas, concepts, tools and methods, and importantly, scientific literacy as/for transformation:

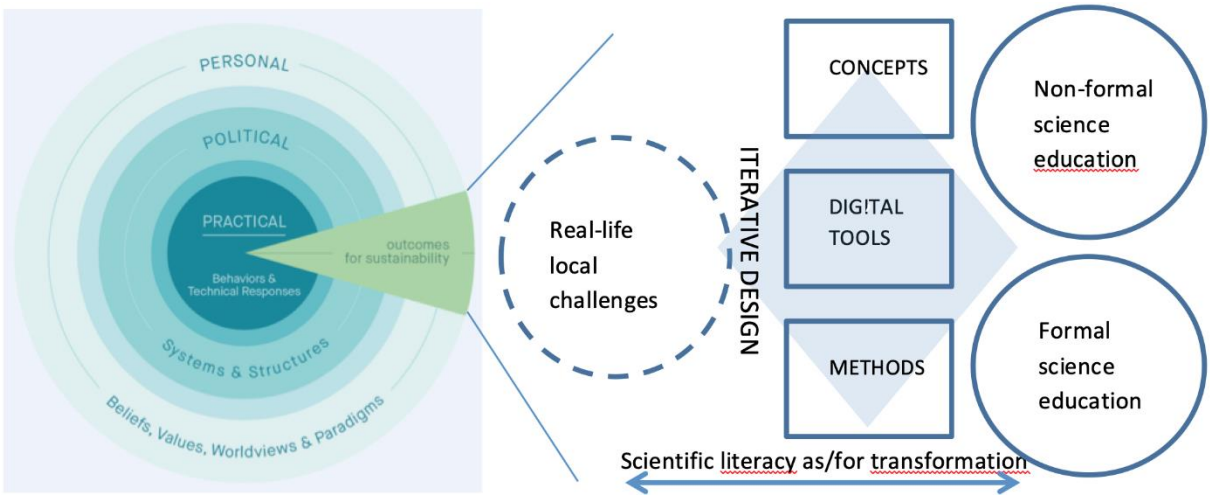

Figure NO2: SEAS original model

From the text immediately below the figure: «Accordingly, the SEAS coordination and support action builds upon the assumption that developing scientific literacies useful for 21st century learning contexts involve not just acquisition and use of scientific knowledge but rather developing skills of scientific inquiry and argumentation through transformational action in real contexts. From this view,

scientific literacy is about applying and adapting scientific knowledge and methods to real-life challenges" (SEAS project description). However, what is evident from the cCHALLENGE data is that science do not have a preconditioned position in the description and analysis of transformational processes. This is a well established fact from earlier studies of scientific literacy for social action and everyday practical concern. The model may instead start from a more fundamental notion: that of literacy as making sense of encounters that are at least partially textually mediated. Even scientifc literacy in a disciplinary sense, seen from a literacy perspective, involves learning to master a set of practices that are to a large extent textually mediated, sometimes constituted by texts (texts as constitutive of the situation) or in the background (taking a supporting role, like taking notes of observations). Using and transforming textual resources into new text as part of inquiry and action is commonplace in school science (Knain, Fredlund, & Furberg, 2021). However all practices, more or less specialized, can be seen as "mediated by literacy and that people act within a textually mediated social world" (Barton, 2001, p. 100). In open schooling design supporting students to act in sustainability isses, literacy would entail to make and use texts of all kinds for sense-making, building social relations, make social action; take part and act; negotiating identity, culture and power-relations along the way.

In figure 1, open shooling encourages students to move across everyday life-worlds and formal and non-formal education; which can be seen as a series of literacy events across open schooling settings. However, literacy is also a source of learning when the series of construals of experience and social enactments are brought together in a entity that can be recognized units of meaning that transcends, but are still related to, the richness of own and other's experiences. The digital tool of cCHALLENGE allows for scientific literacy as/for transformation by offering a resource for meaning-making supporting action for making change. The analytical framework presented below specifies qualities that are important in interpreting and identifying such relations.

Intertextuality is a complex phenomenon. In her survey of the historical origins and development of the notion of intertextuality, Alfaro (1996, p. 268) introduces the term this way: "The concept of intertextuality requires [...] that we understand texts not as self- contained systems but as differential and historical, as traces and tracings of otherness, since they are shaped by the repetition and transformation of other textual structures." A main contributor to this notion is Bakhtin, in his trialogic perspective on the utterance, it is located between preceding utterances on the one hand and the anticipated response on behalf of the addressee on the other, and "any utterance is a link in a very complex chain of other utterances" (Bakhtin, 1986, p. 68).

In the research literature, intertextuality is connected to terms such as voice, style, appropriation, and discourse role. (Bazerman (2004, p. 86) has defined intertextuality as "The explicit and implicit relations that a text or utterance has to prior, contemporary and potential future texts". However, intertextuality is concerned with not only texts, but also the contexts associated with them. Acts of meaning rely on an interdependency of text and context; when we encounter textual expression, we shape expectations about the situations where it was uttered, and for a given situation we have expectations regarding what might likely be said. Thus, intertextuality is also about evoking events,

encounters with phenomena, persons and other texts. Intertextuality connects not only texts but also people with people. Intertextuality leads to re-contextualization as the text-context configuration becomes reconfigured when the text is evoked in another text. The analysis embraces a broad sense of intertextuality that builds on several theoretical contributions (cf. research paper in development for more details), building on, among others, Pappas et .al. (2003), Bazerman (2004), Scollon et. al. (1998). For detailed analysis, the follow typology is used:

-Types of intertextual resources:

1. intertextual links that involve connection to specific texts, written and visual, in various media
2. A prior text is drawn on as a source of meaning to be used at face value, for instance by citation
3. A prior text may drawn on explicitly, by reiteration, content referred to etc.
4. A prior text may used as background, support and contrast (not focused but present)
5. Beliefs, issues, ideas, statements generally circulated in a culture.
6. Implicitly recognizable kinds of language, phrasing and genres and so call on the practices and values that the imported language belong to

Connections to social events

a. Referring to explicit statements, utterances from social events
b. Referring to explicit social events – generalized
c. Referring to a explicit social event
d. Connections to "implicit" generalized social events.
e. Resource of language that vaguely give associations to some prior event or discourse.

Thematic content area and field of practice

The above categories indicates how the speakers orient themselves towards, and focus, particular texts (1), events (2), and themes (3). The qualities envoked by these links, together with their presence (subcategories of (1) and (2)) are traces of meaningful relations to intertextual resources. In order to furthermore interpret its meaning as part of a larger textual whole (meaning at the level of the pharagraph), the intertextual meaning is interpreted in relation to the sentences prior to and after the intertextual relation.

Analysis

The analysis is being conducted using Norwegian data collected within cCHALLENGE conducted in an upper secondary school in a city south of Oslo. The data comprises of cCHALLENGE log entries from 44 students and 6 teaches at upper secondary level.

Challenge themes chosen by students, grouped	Number of students
Nutrition	18
Health/exersice	9
Self-development (reading, writing, hobbies)	9
Reduce consumption, spend less money	4
Reduce time on phone and social media	2
Other, mixed	2
TOTAL	44

The dominant theme among students was nutrition, se table above. Within the theme, students focused on reducing meat consumption, bringing food from home for lunch at school in order to reduce food waste, the use of plastics, or spend less money on unnecessary consumption. Some students also focused on more healthy diet and drinkning more water. Among the concerns involved in this topic, it is in particular the move towards a plant-based diet that has a high impact potential for reducing carbon emissions (Wynes and Nicholas, 2017).

The analysis is a combination of deductive and inductive moves. While the deductive process relies on using the framework as an analytical lens to focus on the readings of the data material and to identify finer nuances of meaning, an inductive interpretation of utterances in terms of the context of the task (cCHALLENGE's 30-day challenge), other entries, and interviews related to the cCHALLENGE work will also be done in future analysis. If the intertextual sources are known (for instance being linked up by the students), the transformation of these resources (what have been included or used, what is left out) is investigated.

Preliminary results

An inspection of a selection of five of the most developed (in terms of number of entries and length of entries) cCHALLENGE logs indicate that

Line's challenge (excerpts translated from Norwegian)

The student, Line, has chosen this challenge: "Not to spend money on food and drink in the shop during school days". She introduces her challenge this way (Day 2):

> ***My challenge is to avoid buying any food or drink at the store during the school day. I am used to buying food or drink at the store almost every single day. I spend extremely much money on the store, something I want to avoid and work on. To achieve this goal, I must be more structured and always have lunch at school. I need to plan more regarding the structure-part. By dong this challenge, I consume less and avoid buying foods that are covered with either plastic or paper. Most ready-to-eat foods are usually covered in plastic. By not buying these products, I***

reduce my plastic consumption. I also save a lot of money, which I can save for another occasion. This is day 2 and I already find it difficult. Kiwi is incredibly close, it is very tempting to go buy a muffin or iced coffee. I hope and believe that the first week will be the most demanding week.

In this entry, she provides some background for her choice of challenge, why it is an important challenge for her, and some thoughts regarding why it is difficult. There are several references to explicit, but general social events (2b), of going to the shop close to school (the KIWI shop). These events are framed as an unwanted habit (A) («to avoid buying any food or drink at the store during the school day»), in contrast to the change towards the more desired habit (B) " to always bring food or drink from home»).

This alternation between these two patterns of social events, is the primary intertextual dynamic in the log, one is past- and current-oriented and is held as problematic by the student, the other pattern is in the near future and is wanted. These two recurrent patterns are through different entries varied by specific socal events (2c). For instance,

(1) I went with two friends into the store, something I should not have done. (Day 2)

(2) Last week I bought an iced coffee, but whithout this challenge I would probably have bought iced coffee every day. (Day 7)

These events (partciular social events – 2c) are interesting, as they can be considered as bridges between the two patterns (buying lunch in the shop, bringing lunch from home). The explicit event (1) is a cause for failing to act as desired in the first instance above, whereas the second event (2) relate a minor setback to a more positive outlook through the reference to the cChallenge task.

Generally, there are very few connections to texts in the material from the Old Me New Me. Those that are present, are however potentially significant. In the extended citation above, there is a mentioning of reducing the consumption of plastics ("Most ready-to-eat foods are usually covered in plastic. By not buying these products, I reduce my plastic consumption.») «Plastic consumption» may be interpreted as a reference to a quite visible discourse in Norway in recent years (issues generally circulated in a culture (1d), as a matter of fact (B). Here, therefore, is a connection between the students' challenge and an environmental concern in society, one which is little contested in public discourse. Later (Day 15) there is a similar unspecified reference to a recent ("now") reduction in the tax on sugar in Norway, which is positioned as negative for students' habits, potentially opening for broader patterns and discourses in society. The day before (Day 14) the cChange team made explicit references to a text (talk and writing):

It probably has something to do with the autopilot we talked about at the beginning of cCHALLENGE and how we make many choices in everyday life without thinking much about it.

[…]

There was a bit about it in the previous post from us, but systems can make it harder or easier for us to live the life we want.It is thus possible that the reference to tax on sugar is a response to the reference to "systems" and everyday patterns of choices.

On Day 21, Line considers that she has been successful in making the change she set out to do. In this reference to general social events (2b), the new, desired pattern of social events (not buying lunch in the shop) as the challenge set out in the beginning, has now become rather a new normal.

Reflections

In this example, the general events are mainly two types: patterns of social events that is held as problematic, and a better way of doing things, as new pattern of general social events.

For the students, the singular experience of explicit, individual events, is in this example case a source of problematizing choices made and related experiences. Possibly, such accounts are important for the student to become aware of habits in the particular choices, and to express feelings related to the choices. The example provides good insights in how challenging changing a seemingly simple habit can be. Through her sustained effort, the student were successful, according to her own assessment. Hopefully, this has given a strengthened sense of agency for making a change in her everyday life. That is likely an important learning experience.

However, from an open schooling perspective it is notable that there are no explicit references to textual resources. Seen from the perspective of the student, this makes sense, as it is difficult to see what sources she would actually need. However, in open schooling environments, it is important that such connections are made. Are there any possibilities for such connections in this example? They may of course be made outside cChallenge, or afterword, but even if limiting the reflections to this example of the 30-day challenge, there were opportunities making such connections in a couple of instances that may be interesting from a subject didactical perspective. The reference to consumption of plastics referred to, could be a seed for inquiry into a broader discussion of consumption patterns in society and their effects on human health and ecosystems. The reference to sugar taxation likewise. A possible suggestion would be that students engaged in interdisciplinary open inquiry projects in school while conducting the 30-day challenge, that were related to their personally selected challenge, as a soft integration between cChallenge as resource and school teaching.

The cChallenge framework emphasizes through the "three spheres" model, the importance of relating practical change with a political and systemic sphere, a sphere of personal beliefs, values and world views. In the feedback from the cChange team, students were as part of the method challenged to discuss with others (friends and family), look for

ripple effects (other taking up on the change of habits), and to reflect on how difficulties in making change relate to a more systemic level. In this example, some of these "nudges" were possibly taken up by the student, others were not.

Mona's challenge (excerpts in original language)

Mona's challenge was to bring ingredients or food available from home to school and make lunch together with peers. In her first entry, Monca presented her challenge as follows:

> *It's inevitable to have extra food or ingredients from meals we have at home. Some just throw those «left-overs» away even though those are clean and still edible. That's called food waste. Imagine how people are starving at some parts of the world and while here you are, just taking for granted the grains and pieces of food you have. Don't you feel guilty? The challenge is simple yet very effective and sustainable. It's not just preventing food waste but it is also making me save money and reduce my plastic consumption by not buying my plastic packaged lunch from a store or canteen. This challenge is a collaboration with two of my classmates in class, we want it to be social. We came up with this challenge where we will bring ingredients or food available from home to school and then we will make something from it together for lunch, healthy of course. Socializing, money-saving, healthy, and environmental-friendly at once!*

There are references to generalized events, at home, that become related, if implicitly ("Some just"…), to bad habits of throwing away left-overs (generalized social events). This is related to a particular concept, "waste" (1d). There is a strong moral voice in the excerpt, where the problematic habit of waste, and the future, desired for social events become contrasted through "Don't you feel guilty?". Monca also emphasize how important the social experience is for the challenge, and this is a strong thread throughout.

Then follows a number of blog entries with references to particular lunch events, all experienced as successful, where the social dimension is important. The new lunch practices become important and enjoyable as a shared experience. Like in the previous case (Line), the particular social events are important in moving from the old to the new habits. Later in the 30-day period (Day 17) Mona notes

> *These past few weeks of maintaining the challenge I placed myself upfront along with two of my lunch buddies, I reckon the advantages it hands me, personally. And as if the digits in my bank account didn't move or change a bit. As if I was and am completely having fun lunches with my comrades compared to before where as now, ideas, thoughts, and just memories have been brought up to the lunch table resulting into deep, fun talks where not just all of us three but rather more are coming to the circle, bringing their intrigued attention.*

In this account, particular experience and new, emergent practices blur: she raises above the particular experiences to articulate new habits.

There are few relations to textual entities. There is one implicit reference to the discourse of "waste" in the introduction, and later, to "values" related to saving money. Again, as in Line, they can be important connections for teaching interdisciplinary content and systemic dimensions.

Study 3: A multi-layered, posthumanist analysis of narratives of change in the "Ripples of Hope" open schooling project

The case here concerns the annually recurring river festival as a periodical invitation for schools to orient parts of their schooling toward action and engagement of the specific, locally relevant sustainability issue which is the longterm health of the river, but which also and equally evokes the larger, more timeless question of how to re-embed "the human" in the context of more-than-human communities of shared aliveness.

A starting point for analysis comes from posthumanist educational research. Snaza & Weaver (2014) argue that traditional humanist approaches to learning take for granted a radical truncation of what constitutes "the world", equating a very small fraction of the world – namely, the world of humans – with the entirety of world. The Norwegian phrase for "open schooling", *skole i verden*, translates into "schools in the world". If we understand open schooling as *schooling in the world*, and if we accept the principal posthumanist critique against humanism's indecent simplification and truncation of world, then we see that there is an imperative to ask again what constitutes 'world' in the first place. What world-scope we allow – what transparency, what porousness, what permeability of 'world' we invite through open schooling practices –, will have direct consequences for the kinds of questions we are able to ask in the first place, what kind of learning we may or may not expect to document, and what kind of transformation we may or may not work towards. Our starting premise for this case, then, is that the very notion of 'world' is once again at stake. And part of the transformational promise of working with narratives of change comes precisely from problematizing, and then working specifically with recalibrating, deeper assumptions of what it means to re-envision schools 'in the world'. It is an existential concern. For the narrative cosmovision that truncates 'world' to 'human world' – sometimes spoken of as humanism, other times as anthropocentrism, or human-centered metaphysics – has long been understood as being complicit in the unraveling of the more-than-human world (Abram 1996).

This case works across three interrelated strata (see above). So too the concept of narratives for change must be explored and analyzed in ways that reflect this stratified complexity.

The partner school has previously designed a so-called "Ripples of Hope" model, a multi-year service learning-model built on an expansive concept of 'community'. Drawn from a familiar Robert Kennedy speech in Cape Town (1966), the model rests on the assumption that global citizenship involves a commitment to act on the five universal values of honesty, respect, responsibility, compassion, and fairness. Hope, here, becomes the practical face of having integrated these values, and having expressed them through action. Individuals acting on these values will send ripple effects into their nearest family and peer spheres. As students move through repeated articulations of this

model, from one school year to another (on the way encountering and collaborating with various out-of-school actors at the different scales), they explore gradually expansive notions of community – expanding from the innermost circle to the school, to towns and cities, then to nations and global societies, co-acting in ways that concretely perform an experiential knowledge of interconnectedness.

Part of the co-design work for this case involves testing this ongoing open-schooling model in a more explicitly *ecologically* literate context. The concept of "ecological literacy" is here understood as more comprehensive and integrative than "scientific literacies" (Stone & Barlow, 2005). Posthumanism's crucial insight is that the historical division into "humanities" and "natural sciences" was constructed around a bifurcation of human (knowing) subjects and nonhuman (known, studied, so-called 'natural') objects. The largely taken-for granted disciplinary bifurcation into 'humanities' and 'natural sciences', in other words, is built on a contingent metaphysical bifurcation that has now become problematic. Posthumanist approaches to education, on the contrary, open for the potential that education cut across such bifurcations. Posthumanist approaches begin by acknowledging that nonhuman subjects possess *agency* in their own right, encountering nonhumans precisely *as* subjects. They assume that whatever we understand by *the human* cannot be understood in isolation from the manifold Otherness of the world. Others are no objects for human worlds as much as they are the very condition for our becoming human (Snaza & Weaver 2014). This was Heidegger's original insight when he designated being human (what he called *Dasein*) as being-in-the-world (*In der Welt sein*). To work towards open schools as *schools in the world*, then, is also to problematize the contingent disciplinary separation of how we educate the next generations, as they must claim the more-than-human world as the very condition and context for their own existence – including healthy rivers, including a stable atmospheric composition, including thriving forests and oceans and cultural landscapes rich in biodiversity. How, indeed, are schools *open* to the many ways in which humans are *in* the *world*?

The traditional, humanist subject-object hierarchy toward situating ourselves in the world needs to be problematized. From a posthumanist point of view, the researcher-learner-teacher enters into a world of knowing subjects, and of agencies who act on trajectories, scales, and schemes decidedly other-than-human. Researching, educating, and learning becomes less a 'thinking about' and rather a 'thinking with': a participative, immersive practice of situating one's own subjectivity inside a more-than-human commonwealth of subjectivities.

In the co-design process between SEAS and the school, this led to two key moments. These are discussed below.

Encountering Another as Thou

The *first* was a crucial adjustment halfway into the film production process. The original task to the students (while still in 8th grade) had been to trace the life cycle of salmon in the Akerselva River throughout one solar year. Students worked in four groups, with each group focusing on all production aspects for one designated season. A sole field day for filming was marked by the absence of the fish from the river (more site-specific work was hampered by Covid restrictions).

Being seasonal fish, they are known to only be visible in the river upon their return to spawn in late autumn. The overall project design integrated that knowledge, setting the return of the fish as the deadline for completing and screening the film. Upon completion of the film project in November 2021, during the *MOTSTRØMS Villaksfestival*, students reported on an early lack of motivation, a felt distance to the subject matter that did not change until the task given to them was slightly adjusted when the project went into phase 2 after the summer holiday, that is, in 9th grade: now their task became to narrate the entire film from the first-person, subjective point of view of the fish themselves! In the words of 20th century philosopher Martin Buber, students were invited to shifting their research approach from an "I - It" relationship to an "I - Thou" encounter, precisely a shift from a unidirectional subject-object encounter to a multidirectional, hybridized subject-subject encounter. Students reported on a marked increase in motivation to complete the work, and an increased care toward the specific Other they had spent months researching. Recognizing the Other as a subject had become the anchor of their inquiry. It became a potent benchmark for an education toward ecological literacy that integrates scientific literacy proper (understood as a literacy of the strictly natural scientific aspects of their production work, a literacy that was inevitable for their ability to write scripts about the life cycle of migratory fish) into an education not only of the head but also of the heart. It is possible here to argue that the shift toward encountering the Other as a Thou, or subject, was a shift with a concrete *mobilizing potential*. Religious scholar and environmental ethicist Bron Taylor writes of this:

> [F]eelings of kinship with species other than our own often animate behaviors that promote environmental health and conservation of biodiversity. These feelings are integrated into an overall worldview, a cosmovision, that includes a cosmogeny (an understanding of how the world came to be), perceptions of belonging to nature, humility about the human place in the world, convictions that all living things have intrinsic value, and love and loyalty to Earth and its living systems." (2021, 30-1)

There is a Dewey'esque element here to be explored in greater depth, namely that relationships are the primordial context for educational experiences – which from a posthumanist educational perspective means expanding the notion of meaningful relationships beyond the human, to include also specific relationships with unique other-than-human subjects (Morris 2014). Literature on ecophilosophy (i.e., Leopold 1949, Næss 1978, Abram 2010, Weber 2014, 2017) and on the role of biophilia for education (i.e., Orr 2004, Louv 2008, Lerner 2015) abounds with perspectives on the importance of concretely encountering Another, typically through direct, sensory, visceral, embodied experience. What is remarkable in that regard is that the I–Thou encounter in this project was largely marked by a conspicuous *absence* of the Other: the point of the film production was to produce it during the fishes' absence and complete it upon their return. In fact, those students who participated in the film premiere at Deichmanske Library 5 November 2021 only ever saw live salmon *one hour* before the premiere, on their way to the screening. This is relevant for the analysis. For it was only through conjuring the Other through the imagination – through scientific research, narrative, imagination, drawing – that the students were able to encounter the Other. This warrants further discussion, as it potentially adds rarely observed phenomena and relevant insights to the literature.

It is in that regard relevant to point out also that the project worked with *narrative as itself constituting a method*: inviting the students to become researchers first, then script writers, and then, towards the culmination of the project, to narrate their experiences in researching and producing the film to the public. Using narrative as a method to learn to see through another's eyes, it seems, has itself transformative potential. There is a precedent in the literature. Frans Lanting, in the opening essay to his photography volume *Eye to Eye - Intimate Encounters with the Animal World*, describes how his path of using photography for conservation purposes began when he as a child read Swedish Nobel laureate Selma Lagerlöf's children's tale *The Wonderful Adventures of Nils*. It was this story, Lanting remarks, which first evoked his ability "to see the world through other eyes" and "to celebrate the kinship of all life" (in: Taylor 2021, 32-3). Similarly, Witoszek and Mueller observe:

> Lagerlöf's cabinet of characters undergoes a successive initiation, which brings to mind what Peter Singer called ecophilosophy's 'expanding moral circle': the early Nils is shaken out of his purely anthropocentric horizon of concern, first through befriending a farm animal and thus broadening his moral circle toward a domus-centric outlook on life. Next, the circle widens even further as Nils learns to look upon the world of humans from the point of view of wild geese, allowing him to adopt an oikos-centric—or ecocentric—view of himself (and by extension, humans) … (2021, 70)

There is a line of argument to be developed here as regards narratives for change, that is, narratives as themselves being a potent agent for a change toward a deepened sense of kinship, care, and concern for other-than-human animals.

In terms of modeling open schooling partnerships, this aspect of the discussion leads to these open-ended questions:

1) In what ways can open schooling networks invite students to enter into a world of knowing subjects and agencies other than the human?

2) In what ways can researching, educating and learning indeed becomes a 'thinking with', a participative, immersive practice of situating one's own subjectivity inside a more-than-human commonwealth of subjectivities?

3) In what ways can narratives as method – whether as film, storytelling, performance, art project, or transdisciplinary project – be mobilized as an agent for transformative experiences?

Toward schooling in the more-than-human world

The *second* key moment was not marked by one significant moment but rather by a gradually emerging dialog between researchers and the school on what constitutes the bounds of 'community'. The original Ripples of Hope-model, as it has been conceived and practiced by the school, remains largely within the bounds of a humanist tradition. But our collaboration over time led us to discussing that what we were actually practicing *transcended* humanist notions of community. They needed rather to be understood, in the words of 20th century ecologist-philosopher Aldo Leopold (1949), as a collaboration in and with the larger 'biotic community'. The chosen subject matter, narrative angle, and in fact timing of the film project were closely entangled with a specific *genius loci*, a concrete site at a unique historical juncture. The year for our production

marked the 10th anniversary of the near-total eradication of the river by an accidental 6,000 liter chlorine spill – a now-familiar narrative of collapse. Except that the river rebounded, with migrating and spawning salmon perhaps being the most visible aspect a narrative for change toward a river re-emerging into aliveness. All along, the project was designed to complete at the exact moment when salmon would again migrate up the river, for the film to premiere in-synch with the spawning salmon, near the river. This promise was kept.

In terms of challenges and opportunities with regards to establishing and implementing open schooling partnerships, this second moment particularly warrants further reflection. For the Ripple of Hope-model, particularly as enriched by a posthumanist critique and posthumanist practice, presents a specific opportunity for implementing *more-than-human open schooling initiatives* which no longer perpetuate the received humanist bias of much of contemporary education, but which more directly and concretely explore an education toward exploring our own humanity *in* the context of the living *world*.

There is an inherent challenge in the specificity of the model. As regards the concrete articulation of this local case, the Ripples of Hope-model is not easily abstracted or transplanted elsewhere; site-and-season-specificity is integral to its design. That, however, is itself an opportunity. It can lead to the question: *What articulations of site-and-season-specific, posthumanist open-schooling collaborations around the notion of 'Ripples of Hope' might be modelled in other locations and times?*

Another challenge relates to the question of whether – and how – so specific a project as this can lead to more lasting open schooling partnerships. The Ripple of Hope-model itself is designed to extend across several years, but the specific film project is not so easily repeated. In the case of this school, we have reached a point where the school is inviting SEAS researchers into a thorough debriefing of the previous year and into co-designing follow-up work for the coming year, still and again inside the larger Ripple of Hope-model, but with an adjusted focus (the school is suggesting a reorientation toward indigenous ways of knowing, particularly Sami perspectives on ecology). The fact that the school wishes to continue collaborating with the research community can be considered a success in its own right. But the question remains: *In what ways can more-than-human open schooling initiatives be envisioned in such ways that they have an inbuilt tendency toward regeneration over time? And in what ways can such models be designed in ways that make them relatively less dependent on individual actors, whether in school or outside?*

This is where the project enlarges its design-work towards narratives for change, to consider the Akerselva River itself as a cultural-ecological arena for posthumanist open schooling. From a posthumanist point of view, even a river is not first and foremost an 'environment' as much as it, too, is a tangle of interwoven agencies, both human and more-than-human. A river too *acts*, in ways multifarious, hybrid, sometimes clear and sometimes obscure. If narratives principally unfold where action unfolds, then a river too can be encountered through a narrative lens. This is a clear opportunity: From a posthumanist point of view, we need not only search for 'narratives for change' in the human world. If the world is larger than the world of humans, and if it is suffused with and peopled by far more agencies, then the world in which we necessarily school our children holds far

more narratives to be listened to, tuned in to, explored, studied, participated with, contributed to. Such as this river's: During a time when Akerselva River was a main artery of industrialization for Norway's capital, 19th-century thinker Oscar Braaten envisioned a future when what he knew to be a putrid, rancid sewage canal overflowing with human faeces and industrial waste would become a green, living, and in fact beloved artery (source). A century later, Braaten's audacious vision has become reality. This, and the deadly chlorine spill of 2011, can be narrated in the context of rivers possessing an inherent potential for self-regeneration and self-transformation. And this, in turn, is relevant for the question of what it can mean to co-design open schooling models that contribute to the ongoing transformation toward more liveable, ecologically literate, and socially just futures. For the individual and collective transformations we seek to human meaning-making already unfold inside larger transformations. In both cases – Braaten's and the chlorine spill's – it took a tangle of both river and human agencies coming together to (self-)transform the watershed from wreckage to more aliveness.

This project works towards considering the Akerselva River as cultural-ecological arena for posthumanist open schooling work. It does so concretely through contributing to an annually returning, city-wide sustainability community gathering – indeed, a festival – centred on this largest river of Norway's capital and her population of migrating salmon, and the potentials and challenges therein to establish durable, periodically regenerative open schooling networks working towards narrative for change. The inaugural festival – MOTSTRØMS Villaksfestival – was held in November 2021 on the occasion of the 10th anniversary of the river's death by chlorine. Regeneration and transformation were its core themes, themes that were recognized to have risen right out of place and time itself. From here on, the festival will be held every year in autumn during the time of the salmon spawning, and open schooling initiatives will be given a key role every year, as they already were this first time around. Oslo International School participated in the inaugural public seminar of the festival, aptly named "Learning to Think with Rivers". The seminar will continue as an annually recurring public space where teenagers and adults can meet and share their work towards what narratives for change mean concretely, on the scale of their schools in their locale. The documentary film premiered here. It was embedded in student-led discussion and in other aspects of 'restoring and restorying' (Abram, 2010), including the reporting on another local elementary school's river-oriented artistic work, and including also a discussion with two leading water activists of both the present generation and the famed Alta demonstrations of the late 1970s and 1980s.

This aspect of the project is long-term co-design work, and it is the most difficult to report on as of this autumn. The work will require at least one more, preferably several, articulations for this case to be able to report more concretely on challenges and opportunities with regards to establishing and implementing open schooling partnerships. As of this autumn, the principal model is in place and functional, and it will serve as a blueprint for future articulations. Conversations are begun with three schools for exploring their open schooling contributions to next year's festival, and plans are made to involve more schools from the watershed. The focus here is first and foremost on building structures for future open schooling initiatives that are inherently self-regenerative and self-transformative over time. Structures that are held together, still, by the marked specificity of topic:

this river, *this* seasonal species that remains absent and invisible for most parts of the year, but does return every autumn, inviting, when it does, the larger community of actors – human and more-than-human – in joint work and reflections toward what it can indeed mean to self-transform and self-regenerate over time, year after year, so as to enact principles of aliveness.

Synthesis of findings

Implication to updating and differentiating SEAS concepts, tools, and methods

Study 1 explores the importance of understanding and supporting the integration of the diverse discourses and narratives that constitute learners' worldviews in development during open schooling intiatives. The analyses presented in study 1 suggest that to support and organize students' conscious reflections on their possibilities to act and make critical decisions, we need to recognize contradictions in their talk and elaborate these. Contradictions in discourses and efforts to support integration or overcoming of double blinds is a dimension that could be added to and further developed in relation to the SEAS notion of narratives of change in the planning, implementation and analysis of open schooling initiatives.

The notion of contradictions in discourses and the transformational opportunities that these contractions entail to support knowledgeable transformative engagement should further enrich our understanding of scientific literacies, so that the competence to navigate, reflect upon, and integrate diverse and sometime contradictory discourses that connect (scientific) knowledge and other spheres of life comes to form part of that notion. The notion of languages of possibility itself already enriches the SEAS toolkit, and connects, as shown in the section below on conceptual models, with that of *agency*.

Important implications to be drawn from Study 2 concern cChallenge as a tool to facilitate embedding learning in a transformative framework, which also involves the notion of *narratives of change*. The empirical cases examined show how students construe a 30-day challenge in the cCHALLENGE environment. The students are encouraged to make a change in a habit or concern in their life, and student create a narrative, as a series of events unfolding in time as cCHALLENGE blog entries. These narratives can be rightfully labelled *narratives of change*. Text creation is an essential activity in scool. Teachers spend much time in reading and assessing such texts, also for getting insights into students learning processes, and provide feedback. The framework developed can be further developed into a tool (model) for what to look for in terms of *learning trajectories*.

It should be noted that the method does not favor any particular resource, and lends iteself to discover what is *there*, in students' texts. It does not favor scientific knowledge and methods in any sense. However, when such traces include scientific knowledge, they provides a sense of what resources are available and deemed important, and it is possible to see how they are motivad (why

they are selected), and adapted to the task at hand, which is essential aspects of scientific literacy for citizenship.

Studies 1 and 2 share a concern on integrating different discourses and knowledge resources as a means to support students' literacy and agency. The integration and transformation of different resources for action would require a certain complexity. There is evidence in this case that the cCHALLENGE resource provides a focused and supporting environmnent for making practical change in personal everyday life, and some students reflected on various aspects of this process in the practical realm. But students found little need to seek and discuss knowledge resources or interact with ideas and inquiry into them. Even when prompted for ripple effects and reflection toward the systemic aspects of society by the cCHANGE support team, students rarely followed up connections beyond the practical sphere. This type of development, could be supplemented by embedding the task in a teaching environment exploring such concerns. The analyses indicate that particular events could be key to such connections, and teaching designs should support teachers to look for such instances and then use them for further inquiry.

In addition, open schooling environment could utilize partnerships and physical encounters outside school to strengthen this dimension, which were sometimes restricted due to the pandemic. This would likely cause tensions in the meeting between school as system and the 30-day challenge.

Some aspects of interest for further exploration of didactical implications in further analysis. It is important to consider for this development:

- Students narratives as past directed as well as future directed
- Generalized, familiar patterns of behaviour/thinking interrupted by particular events of significance to the student
- A certain richness of social events and references to ideas, beliefs, ideas, knowledge resources to expand insights.....
- ....and that these are brought together into a new whole shaped by the students when targeting action

The framework and its analysis has provided furhter insights into the concept „narratives of change" in open schooling learning environments. In addition to the issues on contradictory discourses and scientific literacy, study 3 makes the case of considering narratives of change as transformational beyond the individual level by scaling up across the practical and political spheres, in this case, by building up organic recurrent relationships in the larger community. Additionally, study 3 adds the notion of *ecoliteracies*. These are novel ideas and additions that integrate well into and enrich the initial SEAS concepts.

Conceptual model(s)

Our research focusing on narratives of change and languages of possibility builds upon and further expands prior literature suggesting that integrating biophysical and critical discourses might be

needed to address sustainability problems in practice and develop more sustainable human environment relationships (Leichenko & O'Brien, 2015; Leichenko & O'Brien, 2019). To enable the situated learning of real-life problems it has been suggested that socioscientific issues should be learned in local communities, where students can connect with several perspectives and importantly recognize, choose, develop and realize their own interests (Cook, 2015). Developing students own interests in their local community is important as some evidence suggests that autonomous communities are more willing to react to climate change compared to governmentally ruled communities (Marshall, Hine & East, 2017).

Prior research from a cultural-historical perspective has already pointed out the developmental potential that resides in contradictions and in the agents' conscious efforts to overcome them (Engeström & Sannino, 2011). The idea of contradictory discourses as being relevant to sustainability and sustainability education is also present in the literature, and our current research brings these concerns together and advances them further. Building on definition of agency by Emirbayer & Mische (1989), who highlight that to change relationships with structures, an individual or a group rely on the structures themselves, a conceptual model to integrate discoursive manifestations of contradictions and agency in the context of learning towards sustainability is suggested in figure NO3 below.

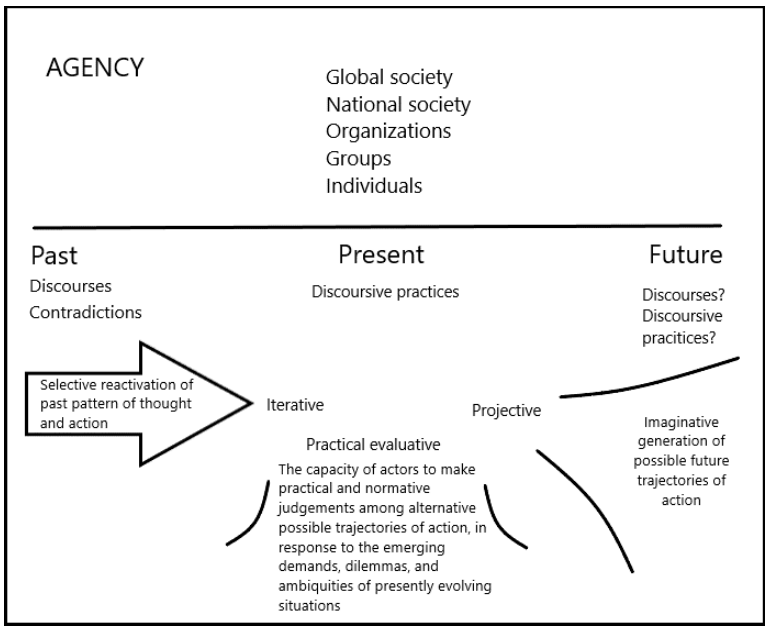

Figure NO3: a conceptual model integrating discoursive manifestations of contradictions and agency.

Dilemmas

Some of the dilemmas raised in study 3 have already been mentioned in the reporting area 1, specially concerning the challenge to scale up and make sustainable school open schooling innovations.

The dilemma of contradictory discourses as it is present in the literature and further advanced in this report is already discussed in the previous section as well. A further dilemma on this regard concerns the observation that, in educating for sustainability, educators need to prepare students to develop critical thinking skills so as to navigate an open-ended and diverse landscape of positions in complex socioscientific issues, yet there is the need to also provide and education in which some domains of expertise are presented and advanced for students. There is here a lingering dilemma between content and method that needs to be unpacked further.

An additional dilemma concerns the fact that expanding from the pratcial action and connecting to school practices does not come easy. The utilizsation of cChallenge means that three practice domains meet: cCHALLENGE and its rationale and design, school as institution with its pattern of behaviours, values and goals, tools and division in school subjects etc, and then the students' everyday life. Two of these are well connected for some students, and that is important. There is however a risk of overloading the student with complexity if the transformation becomes too diverse. A possible solution is to keep the teaching student-focused, but it risks school to become a passive scenery, which is also an untenable situation.

Reporting area 3, Norway: Challenges and opportunities to teaching scientific literacy

Methods

Data sources and Participants

Findings reported in this area are drawn from same data sources in reporting area 1 above, and follow the same analytical procedure. The findings presented here further expand and enter into dialogue with those presented in reporting area 1, but focus on developments facilitated and reported through the Change Lab methodology (see D2.4 for a definition and elaboration).

Findings

Throughout the very many meetings, activities, interviews and encounters that we have shared with participants, often as participant researchers, and that we have documented and analyzed, there are a myriad of insights to share regarding what works and what does not work for teachers generally. Some of these insights have been shared in reporting area 1. Here we will focus on insights gained by attending to developmental processes observed by longitudinally following and supporting—through the organization of change lab workshops/meetings—the development of new pedagogical and organizational ideas. In line with the cultural-historical theory premises described at the outset of this report, each of these ideas emerge always as a contradiction or trouble that is addressed through the meetings and which leads to (a) the development of new cultural means,

concepts, tools, rules, etc… and (b) the establishement of new understandings of what the goal of education in open schooling is (the object of acitivity). Each of the findings discussed here is thus, itself, a dilemma that can be extrapolated into the section below on dilemmas (and which therefore will only be briefly mentioned there).

Overcoming the dichotomy of the practical vs the conceptual (practice vs theory; knowldge vs action) through re-organizing assessment practices and teaching habits and conceptualizations of learning goals: re-configuring the sense of the practical work in open schooling.

A typical dilemma that teachers face when working on project-based settings such as open schooling is that of the challenge to manage or balance the practical, hands-on aspects of the „authentic" activities in which students are to be engaged, and the „learning" some imporrtant disciplinary knolwedge that often is codified, in the educational program, as a learning goal.

When we started collaborating with sub-network 2, they had already agreed on engaging students in contributing to the building of the Cathedral of Hope as part of the Hope in Plastic project. The project involved going out and collect pastic from the shore, cleaning the plastic and helping with their own hands process it at a local fabric producing and recycling plastics, and interacting and entering in dialogue both with the plastic industry, circular economy actors, the SEAS researchers, the teachers, politicians and so on. The practical logistics of such a project are quite overwhelming for teachers—even when coordination with external actors was managed by a member of the leadership rather than by one of the teachers.

A concern begun to emerge in the meetings, where one of the teachers felt she was not being able to connect the „disciplinary" aspects, and was teaching additional lectures that were not connected to the project (explicitly at least) and that covered competence or learning goals stipulated in the respective discipline teaching plans (social studies and geography in this case).

Another teacher in the same group, however, experienced the opposite: she saw in the project all opportunities to cover the required competence goals of ther subject (Norwegian language), and felt the project had been „a present".

We did work the tension between the project being experienced as a „present" for some, and it being a source of stress and of additional work for others. Analysis of the situation uncovered that: (a) the teacher who was struggling to connect the disciplinary themes and the practical, hands-on oriented project, was also operating at an practical/organizational level that allowed for this dichotomy to persist: whe was using one hour a week to teach social studies; another one to teach geography, and a third additional hour that was dedicated to project work. Integrating across these three, while possible in principle, had not been as immedate as if the three hours had been considered as time for the project. (b) In addition, there was a conceptual orientation or habit at play: the expectation that practical work is not disciplinary learning in and of itself, that the teaching has to take place in addition, thus implying additional work. This orientation, embedded in educational practice, could be seen as reproducing an long-standing habit of considering practical, bodily work as less valuable, and conceptual, intellectual work as the goal and value of education.

Throghout the development of the project and later open schooling initatives (Old Me, New Me and The Story of Fredrikstuf), we could trace how the team of teachers transformed both these organizational and conceptual aspects of their work. As we moved on, the team developed, first, a new notion/understanding of practical work as actually relevant in and of itself. The value of these practical experiences in and by themselves as very valuable learning experiences became tangible in the teachers' own remarks and discoursive contradictions: while (some) of they complained they were not being able to connect the disciplinary issues, they on the other hand were emphasizing the many positive observations they had seen, including the students enhanced engagement, capacity to function as a group, to care for each other, among others. By re-considering the value of these experiences, the team developed further trust on investing on those practical aspects, as they were indeed building blocks of everything else they needed to make the conceptual/theoretical connections.

Further, they adjusted their teaching and assessment practices throughout the coming projects: shorter lectures embedded across times throughout the week, and a delayed evaluation strategy, where projects, rather than concluding with a final product (presentation, exhibition, etc…) that was to be evaluated, were followed up by multiple assessment opportunites that themselves connected to further projects. Just as in the teachers' idea, the students' practical work had become more relevant to and ladden with theoretical knowledge, their teaching practice too became an exhibition of connecting the concepts (new understandings) with their practical organizations (new teaching habits and means of organizing teaching and assessment).

Overcoming the dilemma of having to plan, yet being able to be flexible and open in open schooling projects.

Another dilemma or contradiction that teachers face when working in open schooling settings is that of having to deal with emerging possibilties that come from external actors, unexpected twists or inquiry lines that come from the students' inquiry and for which the teachers could not possibly be ready when students go out and about investigating complex socioscientific issues. This dilemma too emerged through the change lab sessions, and was consciously addressed, to some extent, by the collaborating team of teachers. The concept developed to address this issue was that of identifying the basic features they need to plan for, and allowing other features to be undefined. Whereas our findings do not necessarily document what could have worked for every team of teachers, these are examples of the priorities that this particular team developed as a means to address the challenge, in practice. Many of these were discoveries and/or refinements that the team made throughout the project iterations:

- Partners and people involved as the most key, durable, aspect. Planing what the key collaborating partners are to be, and having established a solid collaboration is crucial.
- Planning for the final product(s) the students will deliver or produce. Even though degrees of freedom as to what precisely they will learn and how that will possibly relate to specific learning goals within each discipline are manageable for the team, knowing

what sort of product or products will be the focus of the students' practical activity allows them to envision what forms of assessment and feedback (key to the educational task) are to be given.

- Ensuring that they plan for reflection opportunities, both for them and for the students. A concept the team developed was that of „green house", which was the name given to pockets of reflection that the teachers planned for independently of having a precise plan of what the focus of refleciton or topic was to be. Giving students the time and opportunity to sit back and take in what was going on during the open schooling activities has become a key ingredient in their teaching planing work.

Teacher agency, motivation, and expansive learning in teacher work as key to make open schooling possible and sustainable: the dialectics of bottom up and top down management.

A most recurring topic throughout observations and interviews with all teachers in all of the participating sub-networks has been the challenge and importance of making the teaching work sustainable. In the team of teachers working in sub-network 2, this has been closely related to counting ont he support of the leadership. Here, the dilemma has to do with a balance between bottom up engagement, the work and creativity that relies on the teachers' own initiative and energy, and the top down management, which involves the direction, mandate, and structural support that is provided from leadership. This in many ways parallels the bridge between the personal, the practical, and the political spheres that inform SEAS work.

The case of sub-network 2 is particularly relevant because this school has been deemed by many as an example to follow when it comes to innovating and developing progressive education, particularly with a focus on sustainability. The team of teachers we have worked with has been developing habits and means to engage in such complex but also exciting innovations during long time now, and are a model for many. For example, they were mentioned by an evaluation committee on which the new recent educational reform in Norway was based as a model of progressive education, and as a result of the open schooling activities performed in collaboration with SEAS, several politicians and public figures, including the national TV press, have approached the school (in one of our exhibitions, the state secretary for the environment came as a visitor, and later towards the end of the year chose this school and invited this particular classrom to publically present the governments' new plan for circular economy).

Yet, the focus class that has been the focus of our collaboration has not continuity the coming year, because the school, responding to market mandates of student intake and recruitment, had to prioritize other study lines. This story is not new, as it has happened in two occasions before, where exciting innovative work is mobilized thanks to both leadership support and teacher engagement, but finds not cointinuity and the teachers need to start what they have referred to as a "fight" to re-engage in this kind of activities. This has been a draining aspect for the teachers, who have expressed deep frustration both to us and to their leadership.

While a proper analysis of the details and implications of this case require much more space than this report, it is important to document here this as an example of the limits and constrains that teaching for sustainability and open schooling more particularly face. These are constrains that even these teachers, who have done amazing work cheered by many, face and which make visible the need for considering the work ahead in further expanding the transformational potential of open schooling.

Conceptual model(s)

An ambition that our local network has to make sense of and further develop some of the findings reported above is that of building up a model to account for sustainability in teaching for sustainability. This would be a model building on SEAS initial three spheres of knowledge heuristic depicted in fiture NO2 above, and that would describe the personal, interpersonal-practical, and political conditions for the sustainance and flourishing of open schooling initiatives, both across the school and society and within the school.

Updating and differentiating SEAS concepts, tools, and methods

Many of the concepts, toosl and methods discussed in the other reporting areas above are relevant here too, but to add meaningful reflections rather than repeating what already has been said in other contexts or supported by other data, we will here focus on one of the SEAS concepts that has not been discussed yet (but which could have been raised earlier as well): *expansive learning* and its relation to agency.

The findings reported in this area provide further light into the relevance of considering how learning, when it connects the personal and political structures, bridging them through conscious, intentional work to transform one's own cultural circumstances and constrains, becomes expansive: that is, not only students and teachers but the institutional contexts change. However, our findings show that expanding beyond particular spheres requires of intentional attention to the socio-material structures that afford moving across spheres or domains. For example, in the case of sub-network 2, which serves as the core empirical basis for this reporting area, the many successful levels of development achieved were not enough to ensure the focus classroom continuation, as external forces and conditions made it impossible for the transformational potential to scale up and further expand. These findings therefore provide further nuancing into understanding, in practice, what the three spheres of transformation imply and how connecting this model with insights from cultural-historical theory, inheres potential contributions in the field of transformation studies and of educational for sustainability.

Identifying Dilemmas

Each of the findings reported above is a dilemma that can be further anchored into relevant research literature. When it comes to *overcoming the dichotomy of the practical vs the conceptual (practice vs*

theory; knowldge vs action, this is tightly related to the first dilemma mentioned under reporting area 1 on the purpose of education versus the purpose of practically changing the world through learning.

The second dilemma reported in the findings connects to long-lasting discussions of theory-practice gap in teacher education and teacher praxis. The literature is extense and will not be cited here, but an aspect these findings can further contribute to involves a CHAT take on it would allow documenting the ways in which teachers resolve these dilemmas in and through practical means that also and at the same time involve conceptual developments or new habits of mind.

The third dilemma is commonplace in literature about school leadershiop (e.g., Kezar, 2012), and our ambition is to connect this to teaching for sustainability, the core idea that sustainability is also about personal sustainability, and connect this further with the insights by O'Brien and others that real transformation requires of deep structural AND personal change. Our findings can provide insights in the form of both empirical examples of the type of constrains that are met when scaling up as well as possibly developing a conceptual/theoretical model as described above.

COVID-19 Impacts

Both cCHALLENGEs conducted in Norway took place under lockdowns or highly restricted conditions, which very much limited how the students could experience the change experiment in their regular everyday life and limited the changes that they could commit to. Some adaptations involved the questions: What could be valuables experiences that could be sustained after lockdown, that would be good for sustainability? What are the negative experiences that need to be addressed after COVID, but preferably in a sustainable way?

Additionally some of the project activities could not be completed due to COVID for practical reasons, but also because we wouldn't take teachers attention away (or they simply put the project on hold) because of immediate concerns.

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7. Sweden local assessment

Reporting area 1, Sweden: Challenges and opportunities with regards to the establishment and implementation of open schooling partnerships: The school and out-of-school interface.

Methods

Data sources and Participants

In terms of the establishment and implementation of the network, data sources consist of numerous interactions (approximately 25) between researchers at Uppsala University and other actors during two iterations:

1. During the first iteration, other actors consisted of teachers, educare staff (i.e. staff responsible for care of children that is provided before or after the normal school day), headmaster and students at the primary school Polhemskolan, Visby; moreover, staff at the World Wildlife Fund (WWF), staff at Gotland municipality (planning department and education department) and staff at the County Administration Board on Gotland.

2. During the second iteration, other actors consisted of teachers and students at Vimmerby Gymnasium, staff at the NGO Energikontor Sydost and staff at the education department of Vimmerby municipality. Only sporadic contact with the the actors involved in the first iteration was maintained during the second iteration.

The interactions have included ten workshops, including three ChangeLab workshops drawing on the LORET framework, and numerous online meetings. In addition, informal discussion with teachers and notes from reflection meetings between the involved researchers form a basis for our analysis. The dates for the workshops are given in the table below.

1st iteration (Polhemskolan Visby)		**Actors**	**Focus**
2019-08-08 - 2019-08-09	Workshop 1 (ChangeLab 1)	UU, Polhemskolan	Introduce the project, discussion on focus areas.
2019-09-20	Workshop 2	UU, Polhemskolan	Visit to the school forest, exercises together with children

2019-10-28	Workshop 3	UU, Polhemskolan	Introduction to LORET. Work on thematic topics – ecosystem services, emphaty, scientific literacy etc.
2020-03-19	Workshop 4 (ChangeLab 2 including municipality)	UU, Polhemskolan, Visby municipality	Discussions on waste management, agreement on school forest etc.
2020-05-19	Workshop 5 (including municipality)	UU, Polhemskolan, Visby municipality	Continued discussions on agreement with school forest based on students' input
2020-06-11	Workshop 6 (including municipality and WWF)	UU, Polhemskolan, Visby municipality, WWF	Continued discussions on agreement with school forest based on students' input and experiences from WWF.
2nd iteration (Vimmerby gymnasium)			
2020-10-01	Workshop 1 (ChangeLab 1)	UU, Vimmerby gymnasium, Vimmeryby municipality, Energikontor Sydost	Introduce the project, discussion on focus areas.
2021-02-01	Workshop 2	UU, Vimmerby gymnasium	Discussion on sustainability theme day in relation to LORET.
2021-04-19	Workshop 3	UU, Vimmerby gymnasium	Discussin on continuity of sustainability theme day across years.
2021-04-26	Workshop 4	UU, Vimmerby gymnasium	Preparations for sustainability theme day.
2021-05-08	Sustainability theme day (UU present as observers)	UU, Vimmerby gymnasium,	Presentations by students revolving around theme day topics, eg,

		Vimmeryby municipality	sustainable clothing and climate-friendly cooking.

Analytical procedure and approach

Regarding data collection methods, we have mainly relied on note taking, along with photographic documentation of workshops and meetings (photos of e.g. mappings on whiteboards). In addition, we have made voice recordings of a few key interactions regarding the formal agreement between the school and Gotland municipality.

In terms of studying the process of establishing the network, the data collection has drawn to a large extent on action research theory (eg, Lewin 1946, Argyris 1994). Accordingly, a key aspect of our approach has been to critically examine and reflect upon our own role in bringing the network together. This has been necessary as we have taken on a rather active role in suggesting directions for the action taken by the network. The involved researchers have met regularly in between interactions with the network and reflected on our experience. This working mode aligns with the emphasis in action research on learning through action and the importance of contextual factors rather than universal theories (e.g. Carr and Kemmis 1986). During the reflection sessions, we have drawn on the reflection tool that is presented (only in Swedish unfortunately) at https://www.slu.se/globalassets/ew/subw/mistraec/focus-areas/wp1/reflektionscykeln.pdf. In brief it prescribes that reflective practitioners should follow these steps to critically assess a situation or episode involving multi-stakeholder collaboration:

1. Describe what has happened during the interaction without valuing/normative judgement. The description should provide a brief outline of the context, the involved organisations/individuals, the location, and statements and actions of relevance.

2. Describe stakeholders' (including your own) reactions to the passings: your emotions during the situation, your assessments of the reasons for these emotions, your emotions at this point when thinking of the situation in retrospect, and your assertion of how other stakeholders present felt during the situation and in retrospect.

3. Try to interpret and value the situation. In this step, it is often helpful to draw on scientific theories. In terms of conflictual situations, deliberative democracy theory/discourse ethitcs, power theory or game theory can be useful in sorting out whether the actions and statements are to be considered legitimate.

4. Draw out conclusions from your analysis in step 3. Try to summarise your learnings from the situtation, and discuss in what ways the situation might have been handled in different ways in order to achieve better outcomes.

5. Based on your reasoning in step 4, visualise and describe how you want to act the next time a similar situation arises.

In order to elicit key findings from the interactions among the network partners, and also in the notes from our own reflections as researchers, we have relied on frame theory. Frame theory is based on the assumptions that language shapes practitioners view of the reality (Hajer & Versteeg, 2005), which in turn influences the ways they act (Schön & Rein, 1994). Following Schön and Rein (1994), we define frames as the underlying structures of belief, perception and appreciation that informs practitioners understanding. According to Saarikoski (2006), frames select for certain features of reality and enable people to construct a coherent understanding of them. As outlined by Perri (2005), frames essentially perform two functions. First, they organize experience, i.e. enable people to recognize what is going on by providing boundaries and definitions of what is relevant for attention and assessment. Secondly, they bias for action, i.e. they call for particular styles of decision or behavioural response.

Several studies of frames have shown that people's sense making may be messy and ambiguous rather than linear and straight forward (e.g. Hajer, 2003; Schön & Rein, 1994). According to Hajer (2003), people do not hold immutable and stable beliefs and value positions; instead, their sense making can be organised by multiple frames depending on the practices in which they engage. Thus, it is possible that the same individual draws on several internally inconsistent frames that shape their thinking and actions in complex and unpredictable ways.

There are different views on the intentionality of humans' sense making. Some scholars argue that people are often unaware of the discourses and frames they draw on and unable to describe them with any completeness if asked (Raitio, 2008; Schön & Rein, 1994). At the same time, there are studies showing how people can be reflective in relation to their own sense making (Forester, 1999; Schön, 1983) and that they can use frames as strategically to realise intentions (Entman, 2007). Thus, discourses and frames can also be seen as communicative devices that people purposefully use to make sense of the world and justify their actions (Hajer, 2003).

In accordance with frame analysis methodology, we have searched our data for salient information related to the SEAS objectives and key concepts in our notes from interviews, meetings and workshops, i.e. information that is emphasized and/or persists across different statements and sources. We have interpreted such salient information as articulations of frames.

Findings

By and large, the establishment of the network and the first implementation iteration has worked out according to plan. The frames that we elicit from observations, interviews, informal discussions indicate that the general steps in the LORET framework have been useful as a rough guideline for the work. During the first iteration, it aided in the identification of the school forest as a relevant local sustainability concern that could gather stakeholders for both education and concerted action. During the second iteration, it supported the teachers in making connections between curricula and annually recurring "sustainability theme days" clearer, and it helped them to reflect critically on how to create continuity across theme days and gradually strengthen their impact in terms of local

sustainability. We can draw this conclusion based on our observations of the processes as well as remarks during conversations with teachers and the headmaster of Polhemskolan (first iteration).

Below, we briefly comment on two key findings that we believe are relevant and/or useful to consider also in other open-schooling contexts, and in the further development of the SEAS tools and concepts: 1) the agreement between SEAS key concepts and tools with established norms and practices related to interactions between Swedish schools and their local communities; 2) the pivotal role of the formal agreement between the school and the municipality; and 3) the lack of time being possible to allocate to specific SEAS activities.

1) **The overall logic and objectives of the SEAS project has been easy to explain to teachers, as has the logic of the LORET tool that we have chosen to focus on.** The teachers have not expressed any serious objections or concerns, but also no expressions of surprise or sense of novelty. We assert that a main reason for this is that, at general level, the SEAS project and LORET tool align with established norms and practices related to interactions between Swedish schools and their local communities. Swedish curricula emphasize pedagogic and democratic values in such interactions, and also the importance of students to engage in real-life community challenges in order to develop agency. There are also a number of tools and frameworks available to Swedish schools that promote the same general approach of dealing with sustainability issues in schools as SEAS, including the "Green flag" certification scheme[34] that is widespread (approximately 2700 Swedish schools use it, but not the two that we have worked with in SEAS).

   That said, certain strengths of LORET became even more apparent during the second iteration, in particular **the emphasis in the tool on more continuous long-term integration of open-schooling activities in curricula**. Based on remarks (expressions of frames) given by teachers respondible for the theme day during our workshops, we assert that directing their attention to these aspects will benefit students' learning in terms of sustainability agency and scientific literacy, as the students will be given more opportunities to follow-up on past open-scholing action and reflect critically upon how their impact can be deepened.

2) One key finding from our first iteration that might complement the current outline of the LORET tool is **the pivotal role of the formal agreement between the school and the municipality in the implementation.** The formal agreement has offered a visible and transparent structure for the cooperation around the school forest, and we see in the frames that we have identified through our analyses that it has enhanced the engagement of the involved actors. The possibility to refer to a formal agreement has made it easier for us to get in contact with planners and biologists at the municipality, as well as at the regional County Administration board.

[34] The Green Flag is run by the Keep Sweden Tidy Foundation, and is a partner in the global

Eco Schools programme. Green Flag supports ESE in schools and pre-schools by providing a structure for lectures and activities. The Keep Sweden Tidy Foundation produces teaching material that is used within the Green Flag structure.

The agreement was intended to stipulate responsibilities of the municipality of Gotland and the school (Polhemskolan in Visby) in relation to the use of the area by students and teachers. According to the wording of the agreement at the time of writing, the school will be allowed to utilise the area in ways that go slightly beyond what is normally allowed on public lands, e.g. by putting up nesting boxes for birds and arranging a fireplace. The school pleads to act responsibly and to contribute, if possible, to the preservation of natural values and development of recreational values and other ecosystem services that the area offers, e.g. by picking up litter. The municipality will possibly plead to undertake some construction works, e.g. a rain shelter, based on mappings exercises among the students to elicit how they would like to use the forest. The work on the agreement has also highlighted a bureaucratic obstacle that obliges the school to pay a fee when they leave litter that they have collected in the school forest at the municipal recycling station.

Conceptual model(s)

In order to help us understand and analyse the dynamics during the establishment and implementation of the local network, we have drawn on the model introduced by Cincera et al. (2020) (Table 2; p. 1694), se below. More specifically, we see that the model can help us to reason around the power balance between Uppsala University staff representing the SEAS project, teachers in the local network, and students taking part in open schooling and science literacy activities that we touch upon in point 1 under Findings above, as well as dilemmas involved in introducing new concepts to schools that we discuss in the next section.

Table 2. Overview of the applied categories defining the distribution of power in the programs.

Category	Definition	Examples of codes
Locus of power (central category)	The specific constellation of the distribution of power to shape the program.	
Range of influence	Direct and indirect methods applied by or prescribed to particular stakeholders to influence the program.	Designing instructions for the leaders (designers), control over students' free time (teachers), direct instructions (leader), setting individual goals (students).
Perceived effects	Assumed positive or negative consequences of particular strategies or methods applied by various stakeholders to influence the program.	Student satisfaction, program flexibility, effectiveness, group dynamics, empowerment, authenticity.
Assumptions (identified for the leaders only)	Declared reasons of the program leaders for choosing either an emancipatory or an instrumental approach in the program.	Students' age, group maturity, leaders' experience, leaders' personal preference.
Intentions	Declared reasons for using a higher level of influence in the program.	Higher flexibility (leaders), free time activities (students).

Copied from Cincera et al. (2020) (Table 2; p. 1694).

In their paper, Cincera et al. (2020) analyse the dynamics between stakeholders around outdoor environment education programs: program designers, program leaders, accompanying teachers and students. Key aspects of these dynamics are identified in the leftmost column („categories") in

the table above. We see that the model can help us to reflect upon how easy it has been to deploy the LORET tool in the particular contexts of the local network during the two iterations.

When applying the model to SEAS and starting from the top in the rightmost column of the model, we assert that there is no centralised locus of power (first row in table) over the establishment of the network. In some sense the agenda-setting power of the project ultimately stems from the European Union, the Horizon 2020 criteria for funding, and the researchers who wrote the SEAS application. However, the range of influence (second row in table) of these actors is naturally restricted, both for practical reasons as they are not directly involved in the work of the Swedish local network, and because the concepts and the guidelines for the implementation of the local network function are deliberately chosen so as to give other actors in the network – not least students and teachers - considerable influence over both the practical scope of the work and the interpratation and sense-making of the concepts. Further, as already mentioned above, most of the key concepts such as „open schooling" and „science literacy", as well as the LORET tool logic, are well aligned with ongoing education related to sustainable development in Swedish schools, and as there is plenty of room for the local actors to make their own interpretations and modificaitons when applying the concepts to their practice, the „steering power" of the concepts and tools is rather limited in itself. In fact, in our interpretation, a central assumption (fourth row in table) of the SEAS is that a deliberative use of rather „open-ended" concepts and tools will promote local relevance and empowerment as they are easily adapted to specific conditions of local networks (ie, a perceived effect of SEAS - third row in the table). At the same time, this assumption increases risks of limited added-value if incentives to develop new modes of work are weak, or if practical possibilities for experimenting are lacking. Here, the local researchers involved directly with the other network actors have a responsibility to create engagement, and also room to exercise considerable influence, although in doing so, they have to take into consideration the possibility that challenging teachers and students to go too far outside their established ways of working might be counterproductive in relation to the intentions of the project (fifth row in table). We elaborate further on this below under Dilemmas.

Updating and differentiating SEAS concepts, tools, and methods

As described in the previous section, our findings imply that the LORET tool is well designed for implementation in the Swedish school system, aligning with general values and conceptions in the national primary school curriculum. LORET provides a supporting structure for going from a "theoretical endorsement" of these values to concrete action during SEAS. More specifically, the main steps of the LORET process have been easy to grasp and follow in the project. These steps are:

1) identification of key local sustainability issues (in the first iteration the management of the forest; in the second iteration identification of topics to cover during the sustainability theme day, which in 2021 included sustainable cooking using local ingredients and critical reflection on the social and environmental impacts of the clothing fashin industry);

2) identification of goals (in the first iteration student involvement in and learning on sustainable management of the school forest, in the second iteration outreach activities aimed at influencing the local community to act more sustainable in relation to the topics dealt with during the sustainability theme day);

3) identification of knowledge and values needed (in the first iteration identification of ecosystem services, intrinsic natural values and the empathy and skills needed to manage these services and values; in the second iteration joint fact-finding on the fashion industry and sustainable clothing materials, recepies with local food ingredients with limited environmental and social impact etc.);

4) creating a teaching plan (in the first iteration setting up lessons and other activities that involve students and the municipality in discussions on the management of the forest; in the second iteration reflecting critically upon how sustainability theme days in different years can be better integrated into continuous learning and action on local sustainability issues), with due regard to the fulfilment of the curriculum.

Compared to typical Green Flag certification (which we have studied in earlier projects; see Hellquist & Westin 2019), the LORET project implemented during SEAS has been more focused on a well-demarcated physical place (first iteration) or community (second iteration) rather than a broader sustainability theme. We assert that this is beneficial as it becomes easier to achieve tangible and visible results sooner. A further benefit of the LORET that became apparent during the second iteration in Vimmerby. In Sweden, schools are under pressure from numerous actors including research institutions that are striving to introduce their concepts and ideas in formal schooling activities – both actors concerned with the environment or sustainability and actors who focus on digitilization, entrepreneurship, internationalization etc. In the face of this "competition", the emphasis of the LORET tool on compatibility with the curriculum is an advantage.

In terms of other SEAS key concepts, several of them have been useful when explaining the purpose and logic of the project to the partners during the establishment of the network, including learning trajectories and the capacities attributed to transformational learning. The concept of scientific literacy as defined in SEAS has been more difficult to communicate with the teachers and the headmaster at the school. We found it tricky to pass on the (somewhat cryptic) statement in the SEAS concepts document (p. 18) that „Scientific literacy relates, thus, to "agency" and the ability of individuals and communities to "meaningfully" engage and define sustainability issues, drawing upon scientific knowledge, yet not being in their engagement with the issues determined by it while engaging with the issues at hand." (this notion seems closely linked to, or perhaps a specification of, the concept of agency which is also present in the SEAS vocabulary). Instead, we have tried to convey a more general capacity of students to be able to act as citizens based on scientific knowledge and reasoning, which we believe aligns with the definition in the SEAS grant agreement with the EU (p. 6 in Part B): "This aim recognizes a shift in the understanding of scientific literacy, from the traditional focus on knowledgeability of science content ("knowing what") towards broader purposes of preparing students to handle out-of-school issues in a variety of contexts and tasks as citizens; as

voters, parents, consumers, as individuals and communities enjoying, using and confronting science when it impinges on their daily lives."

At the same time, our impression is that this general notion of the concept resonates well with how teachers and students already view the fundamental function of the Swedish educational system, and we are not sure if it has added value to established practices in the schools that we have worked with - although it likely has highlighted or reminded students and teachers about the potential values inherent in interaction with out-of-school institutions as well as certain skills such as source criticism. As we elaborate in the next section, the broadness of the concept of scientific literacy is connected to the balance that (action) researchers need to strike between enabling and challenging stakeholders in development projects.

Identifying Dilemmas

One dilemma that has became apparent to us when comparing the first and second iterations of the network, and that we have already touched upon in the previous sections, is the balance (or trade-off), from the point of view of local network coordinators/researchers with action research ambition, between, on the one hand, challenging school practitioners and students to step outside their regular mode of work and embrace new concepts and practices that align with project objectives, and, on the other hand, promote local ownership and agency, and also perform studies of practices that are genuine in the sense that they are integrated in the regular education and based on established discourses and institutions rather than free-standing project activities.

In some sense, this dilemma is ever-present in development projects, and we have certainly encountered variants of it before. What the two SEAS iterations in the Swedish local network illustrate is that you give up some things no matter how you attempt to strike the balance. During the first iteration, the local network coordinators where rather active and suggested several open schooling activities as well as an overall framework for the first iteration, initiated connections between Polhemskolan and Gotland municipality etc. This ensured data collection in line with the project objectives, but it also caused the teachers to take a step back and rely rather heavily on our coordination.

During the second iteration, we chose a slightly different approach, keeping the experience from the first iteration in mind, and also for practical reasons during the worst months of the covid-19 pandemic. We introduced the SEAS key concepts to the teachers in the local network and then gave them plenty of room to integrate them into their ongoing planning for the sustainability theme day. In one sense this was "too easy" for them, as it seems that common interpretations of eg, "open schooling" or "scientific literacy" align well with established practices in Swedish schools and therefore do not necesseraly by themselves challenge the status quo or provide directions for new work modes.

Reporting area 2, Sweden: Challenges and opportunities to transformational engagement, scientific literacies, and motivation

Methods

Data sources and Participants

The data sources and participants are by and large the same as those described above under 2.1.1. In terms of studying transformational engagement, scientific literacy and motivation during the first iteration together with Polhemskolan, data sources also include observation of i) classroom teaching, ii) outdoor teaching in the school forest and iii) teaching at a science center in Visby. Outputs from these sources include drawings and shorter texts by students.

During the second iteration together with Vimmerby Gymnasium, data sources in addition to those described above under 2.1.1. include responses from 42 students who answered to pre test Global Assessment Instrument survey, responses from 219 students who answered a short evaluation survey following the sustainability theme day that was designed by teachers at Vimmerby Gymnasium (questions included in this survey focused on whether the students had appreciated the theme day, what they had learnt, if they will change their own behaviour in any way following the theme day, and if anything could be done to improve coming theme days), and output (notes) from semistructured interviews with 13 students.

Analytical procedure and approach

We have drawn mainly on action research methodology and frame analysis as described under 2.1.2. However, the results from the GAI and the sustainability theme day evaluation survey have been interpreted with a more quantitative approach,by identifying frequency distributions of response options in Microsoft Excel. Results from the evaluations surveys informed our questions during interviews.

Findings

First iteration (Polhemskolan):

In terms of transformational engagement and motivation, our assessment based on the data sources including student output is that the work on the school forest according to the LORET model has provided opportunities for transformational engagement and motivation. In terms of "transformational engagement", we feel that it is useful to connect the term to development of empathy and sense-making. We see that our purposeful division of mapping of values attached to the school forest into i) ecosystem services (i.e. an anthropocentric view) and ii) intrinsic values has been beneficial for the sense making and also emphatic reflections among teachers and students (and possibly also among municipality staff, although there is less empirical support for the latter). In addition, some of the exercises that we have suggested and co-designed together with the

teachers are specifically targeted at developing empathy in relation to organisms in the forest. In one of these exercises, aimed at younger children, participants first maps out proverbs or sayings that are based on animal metaphors, e.g. "old bat" or "clever as a fox". Then the children reflect on i) the accuracy of the proverbs and ii) their possible implications and effects when used.) Based on reports from teachers, these exercises have been useful when performed together with students (we have not observed these sessions ourselves unfortunately).

Adding on to our reasoning around the formal agreement between the school and the municipality on the school forest under 1.2, our analyses (observation of discussions among teachers and reports from teachers on their discussions with students) strongly suggest that the agreement has enhanced motivation among teachers and students. They express hopes that the agreement will have a tangible impact on the physical planning and natural resource management of the school forest area. Our analyses also suggest that the sense of progress has been important, as new paragraphs have been added to the draft. Using the SEAS vocabulary, the agreement can thus be seen as a formal expression of an emerging *narrative of change*.

In terms of challenges encountered during the project, some unforeseen events have actually been beneficial for learning, and possibly also motivation and certain aspects of transformational engagement (and also the critical thinking referred to as a capacity to be developed by transformational learning according to the SEAS concept document). On the first visit to the school forest at the onset of the project, the children found a glove filled with drugs hanging from a tree branch – a sign of drug dealing in the area. Along with litter including liquor bottles left in the forest by groups of young people spending late hours there, this event was challenging, as it raised concern and doubt regarding the feasibility and appropriateness of focusing on the area. But it was also an entry point to discussions on the role of natural areas in cities and limitations and scope of the Swedish legislation surrounding the „right of public access". Another challenge encountered was the discovery that the school was obliged to pay a mandatory fee for depositing waste at the recycling station in Visby after having collected litter in the school forest. Although unfair and discouraging in some senses, this event sparked discussions on inevitable costs associated with waste management. Reports from teachers indicate that students exercised critical thinking during these discussions.

A different kind of challenge we have identified through our anlayses is the effort needed to break away from anthropocentric perceptions of nature among students (not in order to replace these anthropocentric views, but to complement them with other notions). When students first mapped out values assigned to the forest and desired developments (using SEAS vocabulary, they pursued a democratized inquiry), they almost exclusively focused on use values (i.e. services that would accrue to them personally, such as recreational opportunities). However, when the concept of intrinsic values was introduced to the students, the scope expressed by the mappings widened, as e.g. organisms, habitats and food chains were included, illustrating a *learning trajectory* in terms of a broadened understanding of the area.

Second iteration (Vimmerby gymnasium):

In terms of students' motivation and attitude towards science literacy, the pre-test GAI strongly indiciate that the responding students are heavily tilted towards a "conservative natural science" interpretation of the concept. This shows e.g. in the large proportion of respondents who disagree with the statements that "Research the quality of news to find out the share of fake news" or "Debating competition - two students argue for a pro or contra position on a given topic" are examples science, and in the large proportion of respondents who agree with the statements that "Experiment with coins that show the surface tension of water" and "Measuring your personal electricity consumption as a basis for implementing energy-saving measures" are examples of science. The students further seemed to have a reather bleak outlook of their own potential to engage in scientific activities. A majority disagreed with the statements that "I make suggestions about how to improve activities related to science", "I felt interested in topics related to science", whereas roughly equal proportions agreed and disagreed with the statement that "I participated in discussions related to science."

The interviews with the Vimmerby Gymnasium students indicated that they did not clearly connect their work during the preparations for the sustainability theme day to science eduction or scientific methodology when posed open-ended questions. When prompted to reflect on certain aspects of scientific literacy, they however stated that sources criticism was an important aspect when compiling information on the sustainability issues that were to be presented during the sustainability theme day. Most respondents felt that the work had not increased their interest in careers within science, although some of them stated that scientific work was something that they could imagine doing irrespective of their experiences connected to the sustainability theme day.

As only very few post-test GAI survey could be sent out following the sustainability theme day, due to time constraints, it has unfortunately not been possible to establish individual *learning trajectories* using that method. Howver, the short evaluation form sent out after the sustainability theme day as well as our observations during the preperations before and execution of the theme day suggest that the process design, supported by the LORET tool, has enabled transformational engagement both and scientific literacy in the more action-oriented sense stipulated in the SEAS concept compilation. A majority of respondents stated that they have learned gained new insight on sustainable clothing and food with limited climate impact (ie, the two focus topics of the sustainability theme day), and a majority also stated a willingness to try to change their own behaviour in relation to these topics. However, there was also a fairly large proportion of respondents (c. 8%) whose answers indicate nothing but a rather "shallow" learning outcomes on the general subject of sustainability (as illustrated in statements such as "we need to take care of the environment", or even "nothing"). Further, our observations during the preparations and the theme day itself indicate that genuine transformative engagement was developed in only a minority of the students – those who were most engaged in the practical arrangements and presentations and other outreach activities (developing a website etc). When asked to reflect on our observation during the interviews, the respondents confirmed that some groups are students were not very engaged. They asserted that the observed pattern could partly be explained by different engagement among teachers, but most suggested that the most important explanation was varying levels of personal interest in

sustainability issues among students at the onset of the project. The respondents were asked to reflect on possible ways to engage also students with low intitial interest. While they asserted that it would be difficult to reach many of these students, they suggested that taking personal interests and hobbies (eg, cars) as a starting point for the teaching might help.

Our observatrions point to a potential general dilemma in open schooling activities that aims at involving whole schools or large groups of students that we elaborate on in the following sections.

Implication to updating and differentiating SEAS concepts, tools, and methods

Our remarks regarding the concepts of transformational engagement, transformational learning and co-design that we gave in the first Local Assessment Report (which see) are still valid, but we don't restate them here. Instead, we point to a possible development potential that we see in the LORET tool.

As we indicate in the findings from our second iteration together with Vimmerby Gymnasium above, we see a challenge in combining, on the one hand, the strive to work with real-life local sustainability challenges and make an impact on local policy and effectively collaborate with other local actors, and, on the other hand, to make the activities inclusive enough for all students in the school to gain comparable experiences and insights and participate on equal terms. It seems that there is room for addressing this challenge in the further development of the LORET tool. One aspect of this challenge is the question how power dynamics and diverging interests are handled at the very onset of the process, when the local sustainability challenges are identified and framed. It seems inevitable (and it may well be legitimate) that some teachers and particularly engaged students take a lead role during this step, but additional conceptual tools for analysing these dynamics would be welcome.

Conceptual model(s)

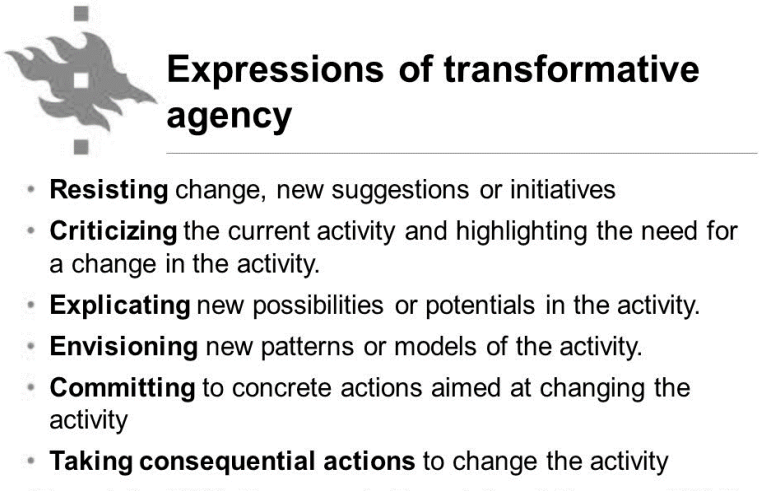
We see that the challenge that we outline in the previous section, ie, in combining, on the one hand, the strive to work with real-life local sustainability challenges and make an impact on local policy and effectively collaborate with other local actors, and, on the other hand, to make the activities inclusive enough for all students in the school to gain comparable experiences and insights and participate on equal terms, can be related to several models.

First, it could be used as a basis for expanding the scope of the model by Cincera et al (2020) that we already discussed under 2.2.3. In particular, an uneven involvement of students in open schooling activities can be analysed in terms of the "range of influence" (second row in table), "perceived effects" (third row in table) and "intentions" (fifth row in table). A possible implication from our observation is that there may be a tradeoff between providing a large group of students with a sufficient range of influence to achieve acceptable effects/intention in terms of equal learning (or at least equal learning opportunities), and, on the other hand, achieve effects/intentions in relation to tangible outcomes in terms of sustainability in local communities. Howver, the dynamic might be even more complex, as the tangible outcomes are connected, according to the assumptions in open

schooling literature (fourth row in table) through a feedback loop with certain intended learning outcomes, such as motivation and transformational engagement.

Our observation can also be analysed using the "expressions of transformative agency" typology developed by Engeström (2011) and Haapasaari, Engeström & Kerosuo (2016) (see illustration below).

List of expressions of transformative agency (based on by Engeström 2011 and Haapasaari, Engeström & Kerosuo 2016):



We assert that the uneven distribution of student involvement in open schooling activities can be described in terms of the different expressions of transformative agency. In terms of our observations during the first iteration together with Polhemskolan, which is small school with few students, we assert that the most students were exposed to the „criticizing" (identifying and criticizing littering in the school forest and inadequate municpal waste manegements routines), „explicating" and „envisioning" (deliberating on ways to manage the school forest better) and „committing" (developing a draft agreement) expressions of transformative agency. By contrast, in the second iteration together with Vimmerby Gymnasium, we assert that rather large groups of students in the school were mainly exposed to the „critizing" expression, and some of these even expressed some „resistance". However, a majority where also exposed to the „explicating" and „envisioning" expressions, while seemingly only a minority could be engaged in more „committing" expressions.

Identifying Dilemmas

Our reasoning in the previous sections can be formulated as a dilemma. There is a trade-off between, on the one hand, the strive to work with real-life local sustainability challenges and make an impact on local policy and effectively collaborate with other local actors – indeed, this is a prerequisite for certain types of learning outcomes (action-oriented scientific literacy, transformative engagement and motivation) - and, on the other hand, to make the activities inclusive enough for all students in the school to gain comparable experiences and insights and participate on equal

terms. The dilemma can be expressed in terms of deliberative democracy as a model for pluralistic education for sustainable development (see eg, Englund et al 2008). According to this ideal, all students should be given an opportunity to engage in democratic deliberation on sustainability issues and activities, and decisions should be based on. However, to achieve tangible impacts on local communities in a limited time and with limited resources inevitably requires more hierarchical elements (prioritizing among competeing interest among students, appointing smaller groups or individual students to take the lead in terms of engagement with other actors or decision makers etc). These elements no doubt provide valuable learning experiences, but also risk excluding groups of students from fully engaging.

Reporting area 3, Sweden: Challenges and opportunities to teaching scientific literacy

Just as new or particular forms of interdisciplinary science learning for action and engagement towards sustainability are expected in open schooling innovations, new challenges and opportunities to teaching in these types of innovative settings are expected too. In this section, local networks are expected to provide with assessments on progress, challenges and opportunities documented in this regard. Particular emphasis is made to teaching strategies in the classroom, outside of the classroom, as well as on the collaborative challenges and opportunities that emerge in the collegial relationships, both within teachers and across teachers and school leaders.

Data sources relevant to this area include but are not limited to classroom and field (out-of-school) observations of teaching work, teacher planning meetings and meetings involving teachers and teacher leaders, as well as co-design workshops including teachers and focusing on teaching strategies or tasks.

Methods

Data sources and Participants

Data sources and participants are the same as those described above under 3.1.1.

Analytical procedure and approach

We have drawn mainly on action research methodology described under 3.1.2. The findings we report on below are based on observations of activities, on of which (the guessing game about local wildlife) we as researches where involved in suggesting and developing.

Findings

In this section, we first restate our observations regarding the benefits of drawing on a draft formal agreement when teaching scientific literacy that we accounted for in the first Local Assessment Report. Then, we elaborate on our observations from two concrete open-schooling activities during

the first iteration together with Polhemskolan that we briefly touched upon the first Local Assessment Report but that we now can give a fuller account of.

First, **the process of developing the agreement has drawn on legal sciences and research related to physical planning and deliberation about community commons.** It has introduced young students to some aspects of these science areas during discussions on what a municipality is, what physical planning processes look like, what can be done on public land and how such decisions are taken, and the meaning of legally binding agreement. The agreement process has been directly aimed at transformation of local natural resource management, e.g., it can be seen as an expression of agency. In our view, the role of legislation and formal agreements are overlooked in certain discourses on sustainability education and societal transformations for sustainability. To close formal agreements on desired change is a fundamental way of reforming societies in our modern world, and if students are to become change agents it is useful to master this skill.

Our second finding stems from a comparison between two concrete open schooling exercises that strived at combining aspects of sustainability with development of scientific literacy. Both are aimed at young children in primary school (7-8 years old).

Exercise 1: combining programming with reflection on interconnections between sustainability issues

This exercise took place at a local science centre in Visby. In short, the students were asked to program a robot to follow a trajectory connecting visual symbols of the UN Sustainable Development Goals (SDGs) with various sustainability challenges that were placed on the floor. The programming was done by pressing buttons with arrows corresponding to a sequence of moves subsequently executed by the robot on the floor were the sustainability symbols were spread out. The objective was to teach basic programming skills while at the same time reflecting on interrelations between different sustainability issues. During the session that we observed, it became apparent that the children chose the trajectory connecting different sustainability issues rather swiftly and without deeper reflection, and they were not required to fully explain their choices. Further, the number of possible trajectories available to each student was limited due to lack of floor space, and largely determined by which symbols they had in front of them at the onset. By contrast, the challenge of programming the robot according to desired trajectories took up much of the focus during the session. Afterwards, upon returning to the school, the teachers were able to direct the attention of the children back to the SDGs, thereby enabling a discussion on how different sustainability challenges are interconnected. Conversely, in this discussion, the programming aspect of the exercise was absent.

Exercise 2: guessing game to learn about local wildlife and develop language skills and understanding of systematics

This exercise took place in a piece of woodland that has been designated as a "school forest" for educational and recreational activities. In order for the students to familiarise themselves with the wildlife of the forest (not least threatened or vulnerable species) in a playful way, pictures of animals where attached to the students' backs. Then, the students took turns to give each other

clues as to which animals they carried behind them, by describing characteristics of the species. The game ended when all students had been able to figure out the correct answers. The challenge of explaining and guessing which animal is depicted requires students to use their available knowledge about its appearance and biology, while also developing a scientific vocabulary (from biology/zoology) as well as potentially a sense of features that are often used to distinguish between different species in systematics and taxonomy. We could observe that the competitive aspect of the exercise contributed to the enthusiasm among the children, but also that the guessing became a bit rushed and that a certain stress was apparent among those who took longer to figure out which animal they carried.

When we compare the two exercises, we see that they illustrate in different ways challenges and opportunities involved in open schooling activities that strive for development of certain scientific literacy as well as knowledge of sustainable development. Both exercises use an element of "gameification" (e.g. Gatti et al. 2018) to encourage learning. In some ways, this appeared to have spurred motivation in both cases. At the same time, the gaming aspect also appeared to steel some focus from the subject matter – clearly a delicate balance for a teacher to strike. In our interpretation, the two learning objectives of the first exercise (programming and identifying connections between sustainability issues) were not intuitively connected to mimic a real-world challenge or demonstrate useful linkages between the skills to be developed. By contrast, in our view the second exercise was more closely aligned with the real-world challenge of identifying animal species (a crucial skill for e.g. conservation purposes, although nature management aspects were not explicitly mentioned in the sessions we observed). Finally, neither of the exercises involved reflection on connections with local sustainable challenges or potential actions to be undertaken to address such challenges. However, it is easy to see how that could be arranged when combining the exercises with other activities or lessons that draw on the knowledge and skills that students have gained. It is quite possible that the playful and unorthodox methods utilised in the exercises make it easier for the children to recall what they have learnt and apply it in new discussions and settings – indeed a key aspect of scientific literacy.

Conceptual model(s)

The observed activities that we describe above can be analysed based on a variety of models. Here, we choose to briefly reflect on their outline drawing on the selective teaching traditions, originally defined by Östman (1995), as well as on the „teacher moves" described by Van Poeck, Östman and Öhman (2019). See illustrations below for overviews.

Overview of selective teaching traditions (copied from original paper by Östman 1995):

Tradition of ESE	Fact-based	Normative	Pluralistic
Perspective on sustainability problems	Sustainability problems are knowledge-based and are resolved by means of research and information	Sustainability problems are moral which can be resolved by exerting an influence on people's attitudes and behaviour	Sustainability problems are political which should be dealt with democratically
The cause of sustainability problems	An unforeseen result of production and resource exploitation in society	A conflict between society and the laws of nature	Conflicts between humans' wide range of achievement goals
Main method of teaching	Factual information from teacher to student	Transferring sustainable values in student active exercises	Critical discussions based on a number of alternatives
The purpose of ESE	Students receive knowledge of sustainability problems by learning of scientific facts	Students adopt sustainable attitudes and behaviour	Students develop their ability to critically evaluate and take a stand in sustainability issues
The aim of ESE	Citizens who have enough information to judge between different political alternatives in sustainability issues	Committed citizens who accept and approve of the necessary changes in order to develop a sustainable society	Citizens who are competent to engage in the democratic debate and practices that concern a sustainable future
Fact-value focus and relation	Facts	Facts → Values	↕ Facts ↔ Values ↕
Democratic process in relation to education	After	Before	In
Strengths and weaknesses	Based on reliable knowledge Omits the value dimension of sustainability issues	Effective for individual change Violates the democratic and emancipatory purpose of education	Supports democratic competence Time consuming and a challenge to create a commitment

Overview of teacher moves (based on Van Poeck, Östman and Öhman 2019):

Scene-setting	Staging an inquiry	
	Directing	Deepening
Instructing Adding	Confirming Reorienting	Generating Judging

We see that the two activities draw on the three traditions to different extent, but that they can potentially be combined with other educational components that in total make use of all the traditions. The first activity is mainly fact-based, and in itself it give limited room for normative judgements or pluralistic discussions. The second activity is broader in terms of teaching traditions. It is normative in the sense that the SDG:s were described as desirable when the activity was introduced to the students, but it also required a certain fundamental knowledge of certain facts in order to be completed. In the class-room discussion that followed, the activity, the teacher further enabled a pluralistic discussion when asking the students about whether they had disagreed on the optimal path for the robot, and also whether they could prioritize between different SDG:s.

In terms of teacher moves, we see that both activities required „scene-setting" moves from the teachers/staff at the science center. To some extent, both activities also involved „directing" moves, eg, when the teachers confirmed that the path chosen was feasible during the second exercise, or when they provided clues as to which animal was depicted and the students were out of suggestions during the first activiy. We however assert that the learning generated in both exercises would have gained from more „deepening" teacher moves that could have challenged students to consider, eg, alternative paths or conflicts between different SDG:s (first activity), or the conservation status and ecosystem services functions of the animals (second activity).

Updating and differentiating SEAS concepts, tools, and methods

The previous section can hopefully inform discussions on the science literacy concept, in particular how learning about scientific methods can be combined with learning and action related to political societal objectives so that the two components reinforce the learning together rather than confound or work against eachother. The described exercises can also potentially be connected to the concepts of empathy, complexity and meaning-making. The science centre activity highlights the importance of finding intuitively logical and realistic methods when combining different subject areas. The „outdoor teaching" activity described above will likely be institutionalised in the continued educational activities in the school forest.

Identifying Dilemmas

The previous sections highlight a potential trade-off between the introduction of educational elements intended to spur the motivation of children (gameification) and the disireability of directing as much attention as possible to the core issues that the learning is intended to revolve around.

COVID-19 Impacts

Unfortunately, COVID 19 affected the activities in the second iteration quite substantially, as Vimmerby Gymnasium that was mostly closed during autumn 2020-2021. Consequently, only a somewhat limited version of a LORET was executed, and the SEAS project representatives had no possibilities to meet physically with the teachers and students at Vimmerby Gymnasium. We handled this through active participation in digital planning meetings, and we hope that additional interactions (including interviews in person) with teachers and students in person during autumn 2021 will deepen our understanding of the open schooling activities undertaken.

At the same time, the COVID 19 pandemic has naturally advanced understanding of the possibilities and understanding of how some aspects of outdoor schooling, eg, constructive communication between stakeholders and outreach from schools to other actors, can be done online.

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