

# STEAM LEARNING ECOLOGIES

## THE STEAM LEARNING ECOLOGIES METHODOLOGY – FIRST VERSION

### Deliverable 2.2



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## D2.2 The SLEs Methodology – First Version

Work Package	WP2 - SLEs Framework		
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Due date	30/06/2023		
Submitted date	26/06/2023		
Version number	1	Status	Final

## Project Information

Project number	101094648
Start date	01/01/2023
Duration	36
Call identifier	HORIZON-WIDERA-2022-ERA-01-70
Type of Action	HORIZON-CSA

## Dissemination Level

PU: Public	<input checked="" type="checkbox"/>
PP: Restricted to other programme participants (including the European Commission)	<input type="checkbox"/>
RE: Restricted to a group specified by the consortium (including the European Commission)	<input type="checkbox"/>
CO: Confidential, only for members of the consortium (including the European Commission)	<input type="checkbox"/>



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### Quality Control

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Evita Tasiopoulou, Barbara Quarta (EUN)	26/06/2023

### Revision history

Version	Date	Description
0.0	28/05/2023	Draft version
0.1	06/06/2023	Pre-review version
0.2	16/06/2023	Post-review version
0.3	21/06/2023	Pre-templated version
0.4	26/06/2023	Post-templated version
1.0	26/06/2023	Final version



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# Executive Summary

The SLEs Methodology – First Version is the second deliverable of Work Package 2. In this document we lay out a comprehensive methodological framework of guidelines and proposed actions to enable and guide the development of SLEs in accordance with the main foundational concepts in our [SLEs Concept White Paper](#). The work that is presented in this document is based on the outcomes of four co-creation workshops that were organized and coordinated by EA and in which all partners of the consortium participated. The workshops took place during May 2023 (Month 5), each workshop was focused on a particular theme. The themes were: 1. Understanding SLEs concepts and dimensions, 2. Learning by example, analyzing an example SLE, 3. Focusing on SLE prototype development and processes, 4. Consolidating overall methodology. The main objectives of this series of workshops were on one hand to bring together all partners' insights, views, ideas, expertise, and experience towards a co-created constructive methodology, and on the other, to simulate and facilitate a similar process of co-creation that each partner can initiate and implement at local level.

Following the same sequence adopted in the co-creation workshops, we start by presenting a representative example of an SLE to clearly illustrate its main elements and objectives and consequently to better understand what a complete SLE entails.

We then discuss our suggested step-by-step development process that can facilitate and guide the development of a generic SLE. The proposed SLE development process is divided in four main steps, which are: 1. Initiation and Getting Started; 2. Preparation and Establishment of Partnership; 3. Co-creation and Implementation; 4. Reflection and Sharing of Results. For each step, we give a general description, discuss its main objectives, and present the main actions, conditions or prerequisites needed, supplemented with general recommendations on how to successfully complete it. We also include a list of key indicative questions to be thoroughly considered or addressed which can assist the successful completion of each step.

To enhance the readability of the document, we first finish discussing the whole sequence of proposed steps of development and then proceed with accompanying sections that complement them by elaborating on certain key aspects based on the synthesis of partners' insights and recommendations derived from the co-creation workshops. On partnership establishment and stakeholder engagement, and on living lab co-creation practice. As co-creation is being a core and very significant element of the SLEs perspective and development process we revisit the open schooling model and the living labs practice as first discussed in our White Paper. We synthesise and adapt their subsequent steps in our generic development process to produce an easy-to-follow elaborated version, which at the same time we believe will be more appealing to learners and in general to partners of an SLE. It consists of the main stages of “Feel and Imagine” as part of the initiation phase, which then lead to the stage of “Co-create” and its iterative subsequent steps of “Explore, Experiment and Evaluate”, and finally concludes with the stage of “Reflect&Share”. This is the main model process we propose to partners, educators, and other stakeholder participants in the SLEs project to adopt and implement during the piloting phase. This initial version will be refined and updated where needed depending on observations, findings and feedback collected. Possible improvements or needed alterations will be consolidated before the start of the mature implementation phase.

We finish by discussing our facilitation methodology and guidelines. Therein we suggest to plan and offer educators a comprehensive facilitation programme, encompassing multiple modalities, online or in-person, that include hands-on practice workshops, that will not only help teachers, educators and all actors involved to explore, adopt, implement and improve an already developed learning ecology but also assists them to gain confidence and experience towards developing their own ones





individually or in collaboration with other teachers, educators or partners of the consortium. We propose the main design considerations along with general and specific recommendations of features that such a general facilitation programme can incorporate. Partners can further adapt it depending on local needs and circumstances.

This 1st version of methodology as described in this document will be put in practice in the piloting phase of SLEs and will be constantly refined and updated where needed. A final version is scheduled to be delivered on Month 34.





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## Introduction

In our [SLEs White Paper](#) we put forward the concept of learning ecologies to offer a powerful new way to envision and develop impactful local open schooling partnerships as science learning continuum for all. We invoke pathways as a metaphor for thinking about ways to provide structure to learning experiences, about how they are inter-connected and inter-related and about how they allow or help learners to build upon them to pursue goals requiring extended engagement across multiple contexts and learning opportunities. The vision of SLEs is practically manifested in fusing STEAM approach, open schooling environment and living lab practice within an empowering partnership based on local-level collaboration between formal, non-formal and informal science education providers, enterprises, and civil society. In our view of a committed local partnership, we want it to resemble a real ecological system in nature, which has the potential to initiate and generate in time a rich and robust complex system of relationships, interactions, pathways and opportunities of collaboration and development, which was neither prescribed nor predefined. In this respect when designing learning ecologies, we should consider that natural ecosystems both provide and require diversity, efficiency, adaptability and scalability. Ensuring that these features are present in the SLEs to be developed and implemented during the piloting or mature phase of the project calls for a comprehensive and flexible methodological approach to guide and assist the overall development process.

SLEs methodological work, which started at conceptual level with the SLEs White Paper, continues with the current document, D2.2 “The SLEs Methodology – First Version”, which focuses on the practical and procedural aspects regarding the design and development of an SLE as a whole or of its accompanying learning activities. The document is divided into four main sections. The first one presents a representative example of a SLE to clearly illustrate its main elements and objectives and consequently to better understand what a complete SLE entails. Then follows the second section where our suggested step-by-step development process of a generic SLE is discussed. Elaboration and further guidance on key aspects of the development process is provided in the subsequent section. Partnership establishment and stakeholder engagement, living lab co-creation practice, and inquiry-based pedagogical design are the key aspects in focus. In the fourth section the facilitation methodology and guidelines are described. The document closes with the summary.

This 1st version of methodology will be put in practice in the piloting phase of SLEs and it will be constantly refined and updated where needed. A final version is scheduled to be delivered on Month 34.

## Methodology and guidelines

The work that is presented in this document is based on the outcomes of four co-creation workshops that were organized and coordinated by EA and in which all partners of the consortium participated. The workshops took place during May 2023 (Month 5), each workshop was focused on a particular theme. The themes were: 1. Understanding SLEs concepts and dimensions, 2. Learning by example, analysing an example SLE, 3. Focusing on SLE prototype development and processes, 4. Consolidating overall methodology. The main objectives of this series of workshops were on one hand to bring together all partners’ insights, views, ideas, expertise, and experience towards a co-created





constructive methodology, and on the other, to simulate and facilitate a similar process of co-creation that each partner can initiate and implement at local level.

Visual highlights of the online sessions are shown in Figure 1 below.

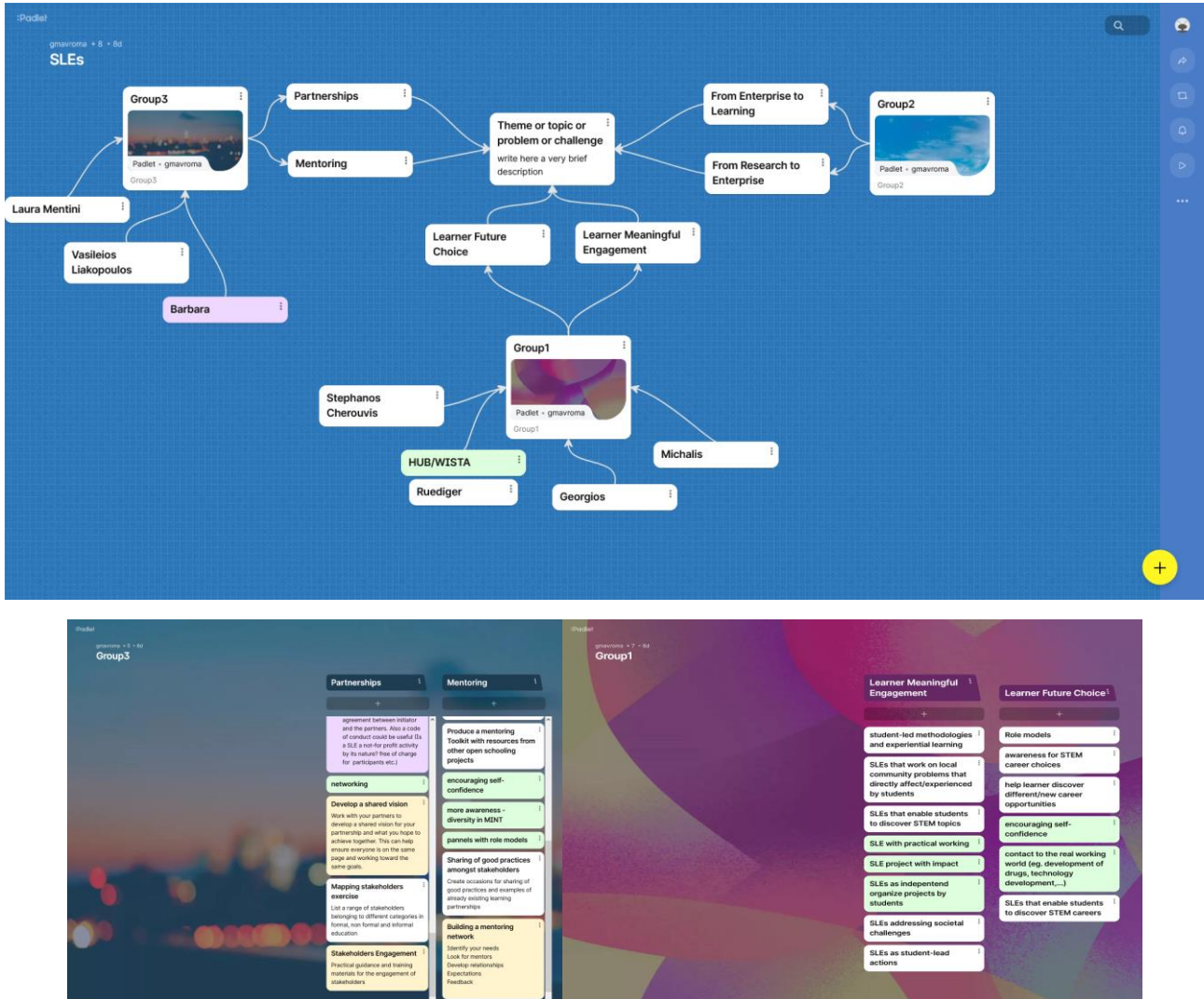


Figure 1 : Screenshots from the online co-creation workshops. Highlights include grouping of participants and concepts, contribution of ideas and insights

Following the same sequence adopted in the co-creation workshops, we start by presenting a comprehensive example of a SLE that addresses all key dimensions as postulated in the White Paper. We then discuss our suggested step-by-step development process. The generalized methodological steps are then followed by separate accompanying sections that complement them by elaborating on certain key aspects. These focus on: partnership establishment and stakeholder engagement, living lab co-creation practice, and, guidance on inquiry-based learning.





## 2.1 Comprehensive example of a STEAM Learning Ecology

In this section we present the details of a representative example of an SLE highlighting its links to each of the key dimensions as postulated in the White Paper. The purpose of this example is to assist partners of the consortium and other related stakeholders such as schoolteachers to better understand what a complete SLE entails. The SLE described below is implemented on an annual basis in the High school/Lyceum of Ellinogermaniki Agogi in Pallini, Greece, as an extracurricular activity for students aged 15 to 16. Every year about 10 to 15 students participate in the activities related to this SLE which start in September and end in May. During this period the group of students regularly meet every week for about two hours.

### 2.1.1 Starting idea and main concept

The starting point is the discussion among teachers and students to think about possible solutions to problems that affect the areas around their school and on bringing up ideas on how they can practically assist local municipalities to tackle the challenges they face. School students after initial search they list and prioritise their preliminary findings to down select those that they will focus on. Then having selected collaboratively one particular focus area, they are engaged in brainstorming on how they can support emergency disaster response planning of local municipalities in case of extreme weather, flood or fire. They take the challenge to design, build, and operate an advanced flying machine, an x-quad drone equipped with cameras and sensors that they can use to map local areas around their school (Figure 2 and Figure 3).

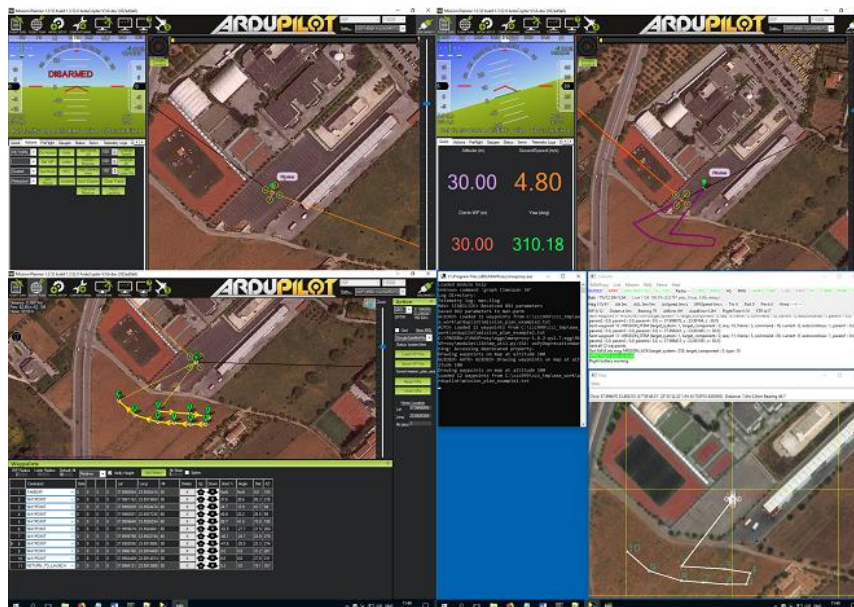


Figure 2 : Aerial views of areas around the school and examples of flight planning.





### 2.1.2 Learning objectives

This SLE gives rise for an overall educational project and activities aiming at the development of cross-curricular learning within the STEM subjects as well as entrepreneurship. Its goal is to lead to increased motivation and offer incentives for students to develop deep content and concept knowledge, critical and creative thinking regarding the everyday use of modern technology along with computational thinking, digital literacy, and problem-solving skills. In addition to these, an analogous SLE with similar constituents can lead to multitude other pathways and directions of developing innovative solutions based on scientific and technological knowledge, or by applying novel approaches such as in the case of biomimicry and nature inspired solutions for e.g., optimal wing or propeller design.

This example SLE as already mentioned is implemented as an extracurricular activity. Having this gives the flexibility to gradually incorporate in it various links to curriculum. In general, curriculum mapping is highly advisable to do when designing SLEs and identifying their learning objectives as this would provide the opportunity of schools to design and implement SLEs within their regular school time and not treat them as additional to or detached from everyday school practice.



Figure 3 : Highlights from the drone development stages e.g., construction, on-ground and in-flight testing.

### 2.1.3 Partnership creation

This example SLE prompted the involvement and collaboration of various stakeholders from school education (High school of Ellinogermaniki Agogi in Pallini), local community authority (Municipality of Pallini), higher education and research (National Technical University of Athens, Faculty of Aeronautical Engineering, Pilot Training Academy). Such a diverse partnership gives a lot of opportunities for exchange of expertise, sharing of experience, mentoring, co-designing and cross-fertilisation of ideas among all members. Various aspects of the SLE call for mentoring including those related to career paths and prospects, providing guidance on technical matters, helping on regulations and legal procedures. The partnership fosters also active involvement and engagement through a variety of accompanying activities such as visits to industrial sites and research facilities, and participation to innovation exhibitions and public outreach fairs (Figure 4).





Figure 4 : Highlights from meetings and workshops among industry experts, educators, learners (top), and from sharing outcomes with local community (bottom).

### 2.1.4 Learner meaningful engagement

The example SLE is characterised by its rich and diverse links to curriculum. Therefore, it offers a plethora of opportunities for engaging learners in various interdisciplinary hands-on and experiential learning activities related primarily to the Science-Technology-Engineering-Mathematics curriculum topics. In addition to these, entrepreneurship is in focus as well. In more detail, for each subject domain the direct links include:

- Maths (vectors, vector analysis, solids, statistics)
- Physics (forces, motion, equilibrium, torque, energy, pressure, electromagnetism)
- Informatics (physical computing, sensors, data collection and analysis, user interfaces)
- Technology (3D CAD design, 3D printing, robotics, engineering practices)





- Entrepreneurship (commercial applications, regulations, civic responsibilities)

Most hands-on activities seamlessly call for or include iterative phases of exploration, experimentation, data collection and interpretation and solution evaluation (Figure 5). It is essential that learners, initially in collaboration with educators, and gradually independently and on their own, to be able to make meaningful connections between different subjects and to systematically explore how they can be combined effectively to reach the project objectives. In this context, learners acquire ownership of their learning pathways in respect to both content and process.

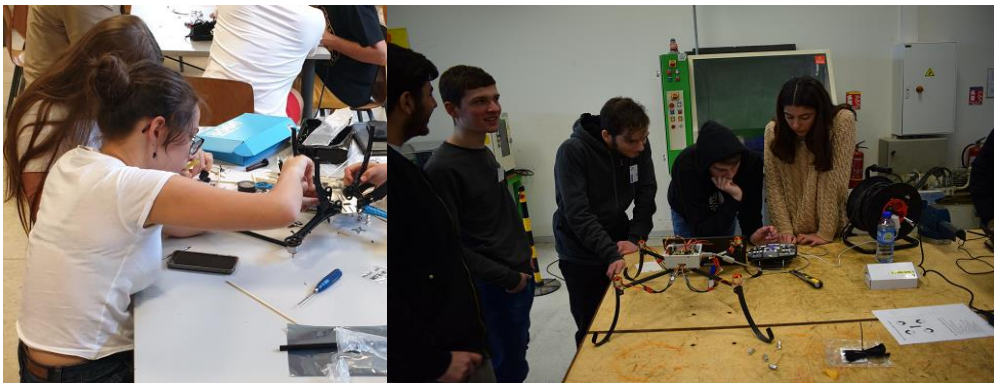


Figure 5 : Learners engaged in hands-on and experiential learning activities throughout the development phases of the project.

### 2.1.5 Learner future choices

The example SLE primarily encompasses STEM subjects and their application to study or solve real-life challenges. In this, learners perform tasks like real scientists, researchers and engineers do for their everyday job, and learn and develop similar work practices and attitudes. Additional to content, concept and process knowledge, students during their work advance their social and verbal skills through collaboration, communication, presentation, project planning and management, and further develop key competencies including creative learning, innovative thinking, problem solving, cross-disciplinary thinking. They also practically develop their digital and entrepreneurial literacy as well, and their social responsibility. They do so for example: by searching and finding information themselves about start-up or established companies in the field of drone technologies and applications, by discussing with members of the partnership about research and possible commercialisation pathways, as well as by seeking consultation on existing regulations and certification requirements. In addition, by thorough thinking and discussing about civic impacts such as in privacy and security.

Altogether, the development and acquisition of these skills and competencies by the students participating in this project is one of its main goals. In other words, the importance of having STEAM-based learning is to help students, on the one hand, develop the skills they need to be successful in the future regardless of the specific path, career, or role they choose to follow, and on the other, allow them to adapt to an evolving and rapidly changing environment better or swiftly.





## 2.1.6 From research to enterprise

An SLE can cultivate broad thinking about existing or future applications and enterprises starting from research spin-offs addressing solutions for local needs and challenges. In this example SLE, its particular focus of drone technologies is on the field of disaster avoidance, preparedness, and support. In addition to these, through the partners involved in this SLE awareness is increased for a wide spectrum of other fields of research or/and commercial applications that include the following:

- High-resolution mapping and surveillance with business focus on forestry, environmental protection and preservation, civil/rural engineering, real-estate, insurance, disaster response
- Inspection, monitoring and patrol of infrastructures such as buildings, large equipment, ships, offshore platforms, bridges, highways, power plants, industrial or mining sites, oil or gas pipelines, utility grids
- Agriculture and farming with applications for soil, plant and crop monitoring, harvest control, pest control, livestock inspection and herding

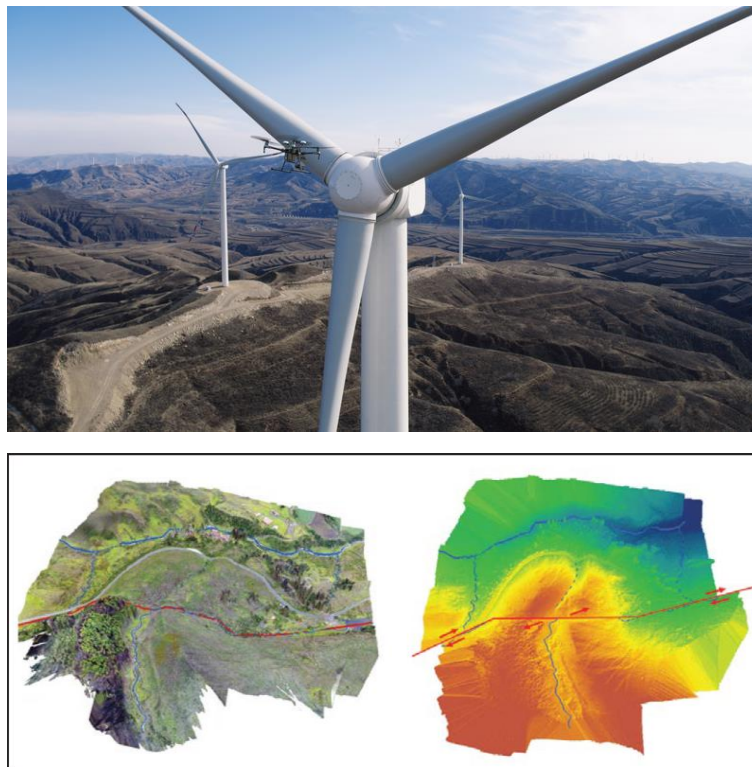


Figure 6 : Examples of applications of drone technologies. Inspection and monitoring of infrastructure (top). High-resolution data collection and mapping for environmental protection (bottom).

## 2.1.7 From enterprise to learning

Expanding the partnership with applied research and industry experts gives the opportunity of sharing insights about future trends and challenges (e.g., future urban air mobility and energy transition/electrification) and the importance of certain key technologies (e.g., 3D-printing for rapid prototyping) and competencies (e.g., digital literacy, problem-solving, design thinking) to accelerate





innovation. Considering these insights, these key technologies and competencies can be included in the scope of life-long learning programmes to address the needs of the present and future workforce.

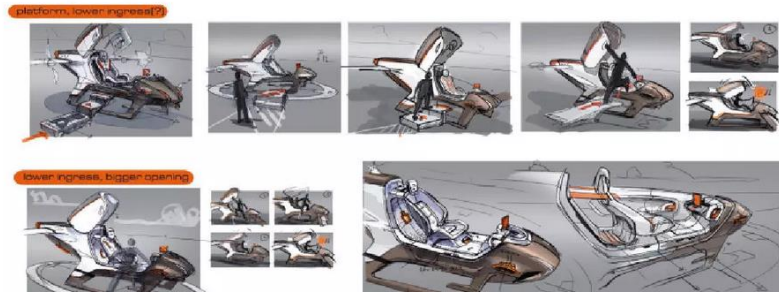


Figure 7 : Envisioning future urban air mobility. From sketch to reality of Airbus Vahana eVTOL demonstrator.

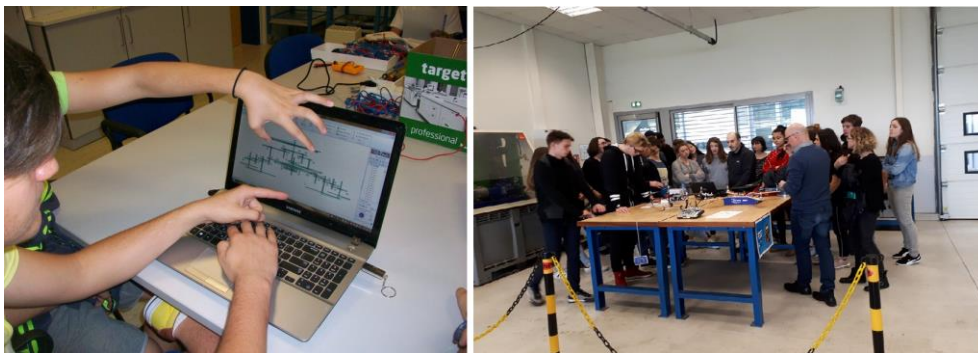


Figure 8 : Highlights of students working “from sketch to reality”. From concept to 3D computer-aided design and to 3D printed prototypes and demonstrators.

## 2.2 SLE step-by-step development process

In the previous section we discussed a representative example of an SLE highlighting its links to each of the key dimensions as postulated in the White Paper so that we better understand what a complete







SLE entails. In this section, we focus on the methodological process that can facilitate and guide the development of a generic SLE. The recommended process as follows below is based on the synthesis of partners' insights and recommendations derived from the co-creation workshops, and of consultation of relevant methodologies in EU funded projects, such as SALL, OSOS, MakeltOpen and others as discussed in the White Paper. This 1st version of methodology will be put in practice in the piloting phase of SLEs and will be constantly refined and updated where needed. A final version is scheduled to be delivered on Month 34.

Our proposed SLE development process consists of four main steps, these are: 1. Initiation and Getting Started; 2. Preparation and Establishment of Partnership; 3. Co-creation and Implementation; 4. Reflection and Sharing of Results. Each step can be divided into multiple sub-steps. For each step, we give a general description, discuss its main objectives, and present the main actions, conditions or prerequisites needed, supplemented with general recommendations on how to successfully complete it. Although the whole process usually can be visualized as a linear path from start to end, often in practice there may be situations that parts of the process need to be iterated or revisited or different pathways may emerge that lead also to successful outcomes. Still suggesting and adopting a step-by-step plan with enough flexibility helps us to provide a constructive and efficient process towards the achievement of our goals.

To enhance the readability of the document, we finish discussing the whole sequence of proposed steps of development and then proceed with accompanying sections that complement them by elaborating on certain key aspects. These focus on partnership establishment and stakeholder engagement, living lab co-creation practice, pedagogical design and framework, and, facilitation methodology and guidelines.

### 2.2.1 Step 1. Initiation and Getting Started

The very first step in establishing a SLE is initiation. It is done by an actor in broader sense, meaning an actor can be for example an individual person, a partner from the SLE consortium, a schoolteacher, or a group of students. An actor can be also an organization such as a public authority, a school, a research institute, a community, or an enterprise. At the heart of initiation is an idea in relation to a problem or a challenge and the willingness to act upon it. Either a problem or an idea that can provide solution to an existing or new problem lie at the core of actors' ambitions to initiate a SLE. The problem or idea can be related to initiator's personal needs and aspirations, the needs of the local community or may have broader societal impact. In other words, there is no imposed constraint with respect to topics or focus areas around which SLEs must aim for.

In the former case, when starting from a problem, the actions lie first in identifying and studying the problem and then finding partners that agree on collaborating in solving this problem to initiate a SLE. In this case an idea or ideas for a possible solution can follow at a later stage, for example, following rigorous research and brainstorming phases.

In the latter case, from an idea to a problem, an idea even at a very initial form can also serve as a starting point for a SLE. An idea can emerge naturally or subconsciously in relation to a new experience or event or from serendipitous search for a solution to a problem. Making the connection between the idea and a relevant problem is key in this case. Based on an initial idea which will then be further worked on and refined, a SLE with other interested stakeholders can be set up.

In both cases the next step to follow is to start seeking for partners. It is up to the actor coming up with the idea, e.g., a user or group of users, private or public organizations or educational institutes, to find





partners who are interested in collaborating on elaborating on the main topic related to a problem or idea. The initiator must search for and contact potential partners with the aim to form a partnership with the capacity to set up a collaborative project that accommodates the key dimensions which form an SLE.

Below we include a list of key indicative questions to consider in advance and think about thoroughly which can assist the successful completion of this step.

- What do we find bothering or problematic in our everyday life?
- What possible solutions can we think of to improve it?
- What is feasible or what we can do to address the challenge identified?
- Has any idea or solution been tried before?
- Can we think of a new or improved one?
- What are the issues and needs of our community at local/regional level?
- What is community well-being? How is affected? How can we impact it?
- What are the societal challenges we are interested in or we are aware of?
- What do we find interesting to be engaged with?

### 2.2.2 Step 2. Preparation and Establishment of Partnership

The main goal for creating a comprehensive partnership in the form of interconnected knowledge ecosystems is to give to all actors, space, opportunities, and motivation to take initiative and central roles in mutual learning and benefit. Bringing together stakeholders from various backgrounds and expertise, the development of new partnerships and collaborations is encouraged that can lead to new opportunities to create and promote a more dynamic and engaging learning environment for all involved (Hazelkom et al. 2015). Thus, envisaging and realising impactful local open schooling partnerships which will involve in and bring together a diverse set of actors from formal, non-formal and informal education, as well as enterprises and the civil society is one of the most difficult tasks in the whole process of developing a SLE.

Therefore, in this step preparation work is crucial to accomplish and establish a partnership. Preparation consists of first identifying and then approaching stakeholders. The starting point to identify potential stakeholders is to make a comprehensive list of all possible stakeholders one can think of. Drawing up selection criteria can also help to make a thorough analysis and finally to select a shortlist of stakeholders to contact.

When in contact, it is the task of the initiator to convince the potential partners to collaborate on the topic of the suggested idea or problem. Although intrinsic interest and motivation is necessary for commitment in a fruitful collaboration, however at the early stages of the development of a partnership it is preferred to aim for an informal agreement rather than a formal commitment. When approaching potential partners to collaborate it is also crucial to have a clear view on how they can contribute to and benefit from the partnership. At this point, it should be noted as well that it is not unusual that an established and promising collaboration fails because the proposed problem is not specific enough or an idea is not concrete enough and clear to all.

Below we include a list of key indicative questions to consider in advance and think about thoroughly which can assist the successful completion of this step.

- Who has direct or indirect interest or motivation to participate?
- Who will be impacted, positively or negatively?





- Who will be affected directly or indirectly?
- Who will be benefited?
- Who do we need?
- Who do we know?
- Who is already in our network of contacts that could make a useful contribution, have interest to participate or introduce/recommend potential partners?
- Who has already been part of a similar project about the issue/problem/idea we have chosen?
- What knowledge, experience or authority is needed?
- Who within our local community or contacts could possibly have similar knowledge, experience or authority?
- With whom have we collaborated in the past?
- What is the level of their availability of learning resources?
- What is their willingness and ability to provide support to learners along their learning pathways?

### 2.2.3 Step 3. Co-creation and Implementation

In SLEs perspective, the key to creating a vibrant and thriving learning ecology is to work across all levels of the learning ecosystem, with educators, organizations, and policy makers, and to start by establishing local partnerships as the driving force of learning ecologies in which everybody contributes and benefits. And in which all participants share a common intention of embracing the complexity that surrounds an individual's experience of learning and development in the various systems and environments (Pritchett 2013). This emphasizes the value of meaningful co-participation and co-creation of activities, mutual respect, and responsiveness from the entire environment. It suggests that both young students and lifelong learners are capable of being relatively independent and self-directed when they are given freedom and sufficient opportunities to participate meaningfully in authentic activities across the learning continuum (Baker 1999). This also entails educators in all types of settings within a learning ecology recognizing young learners' interests, skills, and personal areas of expertise, building on what they bring to the learning experience, supporting them in integrating these into their learning and helping them find a way to deepen them, explore and see how these can extend into the future by following relevant studies and careers. It crucially involves building on one's prior knowledge or making seamless connections between e.g., the science curriculum and science in the broader world, across time and settings throughout the day and across the lifespan (Hannon 2017).

Creating a project that entails all above is the next step to follow in the development process. Namely, having established a partnership and decided to develop the idea of a solution to the selected collective problem, the partners have then to take the action of co-creating. This can be done either by following an existing initiative or process as the one proposed in the living lab co-creation practice or by setting up a new one that better suits their needs and objectives.

Whether a project is set up or connected to an existing one, it is important that all stakeholders in the partnership are included from the start to meaningfully contribute at the co-created and integrated solutions. This requires the initiating partner or partners to actively invite stakeholders to participate in the process as early as possible. It should be considered also that other stakeholders relevant in the context of the envisioned problem or solution can be involved. This includes the end users with which prototype solutions can be tried and evaluated.





Creation and initiation of a project practically means to develop an overall plan. A living lab approach implies that also the plan development process is one of co-creation. In the first step, stakeholders jointly work toward a shared vision for the project. A shared vision, being an integrated result of the joint effort of all stakeholders, fosters satisfaction and commitment among the participants. A precondition for this commitment is that all actors are intrinsically motivated to participate. If one of the stakeholders cannot be convinced that the project is in their interest, the project will not yield integrated solutions and long-term sustainability. This intrinsic motivation to participate should be consolidated in the shared project vision, be it by providing added value in terms of the educational or commercial or social responsibility objectives of stakeholders.

The best chance of reaching mutual agreement and making optimal use of the means, capabilities, and strengths of the various actors, is created when both interests and solutions to be explored are aligned in the development plan. This implies that, if necessary, the aims should be reformulated until all stakeholders' interests are included, which should be part of the plan development process and to which the initiator should be open and accommodative. Thus, it is crucial that all stakeholders of the partnership jointly form an integrated vision and jointly define the problem statement, goals, ambitions and expected outcomes.

Commitment of the participants to be open to adopting an attitude that might be different from their traditional way of working should be part of the shared vision underlying the project in partnership. An open and transparent attitude is needed with regards to expertise, knowledge, interests, and objectives of all involved. Further to being open-minded, flexibility and willingness to adapt may be required before all participants realize how others can help them find new or better solutions to problems.

After having developed a shared vision the next step to follow in the planning is the organization of the various activities that are required to bring initial idea or ideas to final solutions. The activities include iterative phases of exploration, experimentation, and evaluation. Exploration work aims at turning ideas into use case scenarios and rough prototype solutions to be tried further. Experimentation involves testing on real-case situations or conditions to gather further insight and deeper knowledge by collecting useful data that will feed into evaluation. Evaluation is the analysis of collected valuable information during experimentation, the results of which will guide the selection/adoption, rejection or improvement of a particular solution.

The implementation of this iterative process of solution or product development usually referred in industry as “from conceptual designs to prototypes” or prototyping, requires one to actively seek inclusion of useful resources and skills. This usually involves interaction with the people who have, or have access to, these skills and resources or who are willing to develop them through learning. These interactions often take place through a recurring pattern of awareness, action, and interest, leading to better connection and engagement of these people to the project. Therefore, as already mentioned a co-development and co-creation-oriented mindset is crucial to be instilled in the partnership at all levels to encourage the diffusion of resources, skills, expertise, and capabilities.

The aim to ensure that all capabilities and resources necessary for the development process and that all corresponding actors are included in it implies the need for efficient organisation and distribution of tasks, roles and responsibilities. It should be clear that not all partners can contribute to an equal extent or have the capacity or expertise to do so. Hence, it is better if participants first on their own initiative indicate where they can contribute and then altogether jointly work toward the allocation of all required roles and responsibilities.





During the allocation of roles and responsibilities, it should be clear to all what the planned tasks, activities, and expected outcomes imply, and what exactly is expected of each actor. Actors usually need to contribute to the tasks of others as well. Creating awareness and agreement on the commitments, dependencies, and implications of tasks up front increases the chance that actors will adhere to their commitments. However, at the same time it should be noted, that in general a development process can be dynamic and may deviate substantially from initial plans. In this respect being prepared for processes taking unexpected turns or being proactive to avoid so calls for agility, adaptability, flexibility, and resiliency.

Further on this, we should always keep in mind that a learning ecology is being a metaphor of a natural ecosystem which by default is a dynamic, diverse, self-organised system. In other words, the dynamic and unpredictable character of its development and evolution is an inherent feature of the whole concept. Nevertheless, some management structure is needed to track and ensure progress, to monitor the performance of the scheduled activities, and to organize the tasks, people and resources to actually achieve results as planned. The structure does not need to be strict and hierarchical in a conventional way given that most participants may have joined the partnership on a voluntary basis.

Usually, the initiator of a partnership can take the leading role to manage the project and to do so it is needed not only to coordinate and guide the other partners but also to motivate and inspire them.

At the same time, keeping things simple, clear, open, and transparent is key to effective management in partnership. In this direction, organising frequent results-oriented meetings so that all partners get informed about progress or are aware of deviations from expectations helps to maintain the momentum, to remain focused and motivated to contribute. Keeping a positive mindset and active participation of all involved is also crucial in the whole process. As this is greatly depending on or being affected by the sense of accomplishment of results one has also to be prepared for situations where the route to accomplishment may not be smooth or continuous. Periods with ups and downs are not uncommon in exploration and experimentation or in general in any development process. Unexpected problems may arise and setbacks may occur, however these may be a great source of insightful learning about what caused them or how to overcome them instead of being a reason to abandon the effort.

Below we include a list of key points and indicative questions to consider in advance and think about thoroughly which can be useful in the preparation and successful completion of this step.

- Creating a project in partnership is done by following or adopting a process such the living lab co-creation practice. Is this process clear to all participants?
- Are all relevant stakeholders included in the process or is their active participation ensured?
- Is a shared vision co-created that is jointly defining the problem statement, goals, and ambitions of all in the partnership?
- Does it clearly embed all stakeholders' interests?
- Co-creation in practice may require participants to commit to a more open, transparent, and flexible attitude and way of working. Are all aware and committed to this?
- Is an overall plan of activities co-created?
- Is it well divided in tasks or iterative phases of exploration, experimentation, and evaluation?
- Are the expected outcomes or results in each task or phase clearly defined? Are they understood by all?
- Are division and allocation of roles and responsibilities clear to all partners?
- Is allocation based on interest, expertise and capability of each partner?
- Are all aware of and do agree on associated commitments, dependencies, contributions, and implications?





In concluding this step, we would like to emphasise that given the importance of co-creation in the whole development process we dedicate further methodological guidance on it. This is based on the living lab co-creation practice and is presented in the next section.

## 2.2.4 Step 4. Reflection and Sharing of Results

The last step in the process is reflection and sharing of results. Both actions in this phase consist of an integral and essential part of the whole process. Their importance should not be undermined by considering them a formal obligation as part of completing the project or reporting about it outside the partnership. On the contrary, it is an opportunity for all involved to openly think about and discuss the accomplishments, articulate the findings from each participant's own perspective through communicating them to others and collectively reflecting upon all or some of the stages of the followed process.

Reflection on the partnership's overall work, results and processes give rise to new thoughts on what went well or not according to plans, how common mistakes or setbacks could have been avoided, what can be done differently and more efficiently, which were the key elements that accelerated progress or led to better than expected results, what are the overall lessons learned. Reflection includes also rethinking about how the proposed solutions or product prototypes were received by the target population, whether they managed to reach the goals they were intended for and whether any adaptation is required. Thus, reflection can immediately result into reigniting the co-creation process for a new iteration.

As all participants reflect on their own understanding but also compare with each other's assessment and views they strengthen their sense of ownership and at the same time subconsciously consider how to sustain their achieved results or solutions. It is not uncommon that participants focus most of their attention on delivering a solution within certain constraints, and much less on making sure that this need to be a successful solution also over a longer period. Thinking or laying out a strategy about this point of "now-what-next" can actually be initiated in the reflection phase.

Effective sharing of results contributes along this line. Sharing with a wider community of stakeholders is a committing obligation of all in the partnership. It aims at both informing about the tangible outcomes and encouraging and inspiring others to follow a similar approach of action. Various methods and digital or conventional means accessible to the partnership can be utilised such as publications, announcements, participation in conferences, exhibitions, public outreach and awareness campaigns, innovation publicity and networking hubs etc.

Below we include a list of key points and indicative questions to consider in this phase.

- Thinking about the whole project, including its objectives, its participants, their roles and actions, its processes, and its outcomes, what did go well and what not?
- Are all relevant stakeholders included in the reflection process or is their active participation ensured?
- What was the main element or elements behind successful outcomes or what was the main cause of any problems?
- Was it process related, people and attitudes related, conditions or resources related?
- What can be done differently, and how?
- What are the main lessons learned?





- How the lessons learned can be best shared and with whom?
- How achieved outcomes or proposed solutions can be sustained or replicated at wider scale?

## 2.3 Elaboration and further guidance on key aspects of the development process

In the previous section we discussed the proposed steps of development. In this accompanying section we complement them by elaborating on certain key aspects. These focus on partnership establishment and stakeholder engagement, living lab co-creation practice, and finally, inquiry-based pedagogical design.

### 2.3.1 Partnership establishment and stakeholder engagement

In today's rapidly evolving educational landscape, collaboration between schools and companies, universities and other stakeholders is of paramount importance. The vision of SLEs blends STEAM approach, open schooling environment and living lab practice within an empowering partnership based on local-level collaboration between formal, non-formal and informal science education providers, enterprises, and civil society.

These partnerships have the potential to enhance teachers' teaching practices, enrich the learning experience of students, bridge the gap between academia and industry, and ensure that educational institutions are equipping students with the skills and knowledge needed in the professional world. The various stakeholders can also benefit from collaborating with schools by gaining access to emerging talent, contributing to the development of future professionals, and fostering innovation through academic research.

To ensure a bottom-up approach in the creation of the project partnership, it would be optimal for the initiator of an SLE to be a primary or secondary school. Furthermore, we consider an SLEs partnership to be composed of at least three actors: a school and two other actors belonging to different stakeholder groups among those mentioned above. In this section, we will explore a structured approach for schools to establish and navigate collaborations with external stakeholders effectively.

#### *Identifying Shared Objective*

The foundation of any successful collaboration lies in the identification of shared objectives between the school and the other stakeholders which are part of the project partnership. All parties must align their goals and values to create a meaningful partnership. For instance, a shared objective could be to enhance students' employability through practical experience and exposure to industry practices. Another objective can be even more specific and focus on a specific sector or skills that the company introduce to the students i.e., the use of drones for monitoring and improving agriculture. By identifying these shared objectives, schools and stakeholders can work together towards achieving common goals and maximizing the benefits of their collaboration. In the example provided earlier on, the goal of the SLE is to lead to increased motivation and offer incentives for students to develop deep content and concept knowledge, critical and creative thinking regarding the everyday use of modern





technology along with computational thinking, digital literacy and problem-solving skills. This alignment ensures that the collaboration is purposeful and relevant, benefiting both students and the stakeholders.

### *Needs Assessment*

Before initiating a partnership, it is crucial to conduct a thorough needs assessment. This assessment allows both the school and the stakeholders to understand each other's specific requirements, resources, and areas of expertise. A needs assessment may involve evaluating the school's curriculum, facilities, and student demographics and, for instance, a company's industry focus, skill requirements, and corporate culture. Open and transparent communication during this process ensures that all involved have a comprehensive understanding of each other's needs, laying the foundation for a successful collaboration. It also helps identify potential areas of synergy and opportunities for joint initiatives.

### *Collaboration Models and Activities*

Collaboration between schools and external stakeholders can take various forms, depending on their objectives and available resources. A school can engage in a diverse range of activities with a company, university, museum, or local authority to enhance the educational experience of its students. Collaboration with a company can involve career-oriented activities such as internships, job shadowing, or guest lectures/chats, providing students with practical industry exposure and insights. Partnering with a university opens avenues for research projects, joint academic initiatives, academic mentorship programs, and access to specialized resources and expertise. Museums can offer field trips, guided tours, or interactive workshops, enabling students to explore and appreciate art, history, science, or culture. Engaging with a local authority allows schools to organize activities that directly benefit the local community, civic engagement programs, or environmental initiatives, fostering social responsibility and active citizenship. These collaborative efforts between schools and external organizations enrich the learning experience, provide valuable real-world connections, and broaden students' horizons.

### *Access to support mechanisms*

To ensure the success of partnerships between schools, industry, universities, and public authorities, various support mechanisms, that will be accessible by all stakeholders, will be made available via the SLEs project. Access to resources including templates, partnership ideas, guidelines and frameworks already developed within previous Open Schooling projects, will be organised, and made available via the SLEs website. On both European and local level, online and face to face workshops addressing various aspects of the SLEs methodology, will be organised, providing all stakeholders will the opportunity to learn from existing good practices, exchange with other stakeholders, ask questions and receive guidance.

At the same time and within the partnerships, mentoring programs can be established, allowing students but also teachers to benefit from one-to-one support and guidance from industry professionals, university faculty, or public authority representatives. This helps students gain valuable insights, build networks, and navigate their educational and career pathways effectively. Additionally, capacity-building workshops, training sessions, or knowledge-sharing platforms can be organized within the partnership to enhance the skills and expertise of teachers, industry personnel, and







university staff, fostering effective collaboration. Open communication channels and regular meetings facilitate ongoing dialogue, problem-solving, and the exchange of ideas among all stakeholders. By having access to these support mechanisms, stakeholders can foster strong and sustainable partnerships, maximizing the benefits for all involved parties.

Documenting and sharing knowledge among partners is a key element of the project. To facilitate SLEs development, the consortium will create and apply two schemes:

- Ideas and methods to facilitate research-industry-learning synergies, promoting and supporting integrated SLEs projects combining science and innovation application in industry with lifelong learning. To do so, the project will leverage on the SLEs projects to formulate communities of practice bringing together all those concerned or passionate for science education. This will include a dual focus on identifying and enacting opportunities for: a) the application of R&I results in business, including different genres of enterprises (start-ups, SMEs, entrepreneurs); and b) in this industry-based context, providing lifelong learning experiences to various actors (students, teachers, researchers, professionals, etc.)
- Mentoring across the different groups involved in the SLEs to take full advantage of the learning, personal and professional development opportunities generated in the context of the evolving synergies of education, research, innovation, and industry in the local partnerships. Depending on the specific challenge, the right mentor will be identified and will provide advice at development stage, will review actions, and suggest activities and improvements. In each implementation country, the SLEs project partners acting as National Coordinators will support the local stakeholders and facilitate the development and implementation of the respective ecologies. The facilitation of SLEs will include regular planning, support and reflection meetings (online or face-to-face), and training activities. Methods used, knowledge and experiences gained through the SLEs co-creation and facilitation in the early stages and up to the completion of pilot implementation activities, will be informing the mature implementation cycle of SLEs.

In each implemented SLE, the stakeholders, with support from the National Coordinator, will implement the methodology provisions for facilitation and mentoring and for learner meaningful engagement in ways relevant to the local context.

The “Ecologies co-creation and facilitation methods and learning” (project deliverable D3.2) will include a detailed description of the SLEs methods for mentoring as well as framework a set of guidelines drawn from pilot experiences and recognised good practices. This document will offer broad suggestions for content to be built upon by the SLEs implementing entities that they can test and adapt during the implementation phase.

The SLEs coordinators, initiators and participating stakeholders are encouraged to experiment with what works best for their context and to share reflections on their experience toward an effective and innovative mentoring methodology. The local contexts, and participants individual characteristics and needs must always be taken in consideration to implement an effective mentoring activity.

### *Establishing Partnerships*

Once the school and external stakeholders have identified shared objectives and explored collaboration models, the next step is to establish partnerships. Schools can begin by identifying potential organisations that align with their goals and values. Networking events, industry connections, and online platforms can be valuable resources for finding suitable partners. Parents employed within a specific company/university and/or sector, can also help by making that first contact.





When reaching out to potential partners, clear and effective communication is crucial. Schools should articulate their objectives, propose collaboration models, and discuss potential mutual benefits. Emphasizing the value and unique opportunities that the partnership can offer is essential for engaging the interest of prospective partners. Building a strong foundation of transparent communication, trust and mutual understanding from the beginning is key to establishing successful long-term partnerships.

An important aspect to be considered when establishing partnerships for SLEs projects is to consider the pedagogical resources that each stakeholder can offer to the SLE.

### *Building Trust and Maintaining Relationships*

Building trust and maintaining strong relationships are vital for the long-term success of collaborations between schools and companies. Regular communication, meetings, and feedback mechanisms help nurture these relationships. Schools and companies should establish channels for open dialogue and the exchange of ideas, allowing for a continuous flow of information and insights. Sharing successes, challenges, and lessons learned promotes transparency and strengthens the partnership. Confidentiality and accountability should be prioritized to protect sensitive information and maintain professional standards. By actively investing in relationship-building efforts, schools and external stakeholders can foster a collaborative environment that leads to sustainable and impactful partnerships.

### *Assessing the impact of collaborative activities*

Schools and external stakeholders can establish a comprehensive evaluation framework to assess the impact of their collaborative activities. Stakeholders will be collecting and describing artefacts (“learning products”) to be created by students along their learning paths within the partnership focusing on comprehensive learner engagement and reflection on scientific knowledge, skills, and competences necessary for their construction. These learning products will enable an insightful stakeholder dialogue to help assess and redesign learning trajectories and activities provided by the SLEs. The assessment can also focus on specific topics like for example female engagement in the SLEs implementation and female career prospects in STEAM reflected during the various learning trajectories. From this process, specific artefacts will lead to the identification of learning paths and activities that will be used as good practices by the wider SLEs community.

Below we provide some useful resources.

#### For teachers and educators

- Advice from the industry: How can teachers get engaged with the STEM professionals?
- Professionals go back to school: Guide for schools
- Methodology for the engagement of School Living Labs with stakeholders
- A guide to ethics and student engagement via partnerships

#### For companies

- Professionals go back to school: Guide for companies
- InGenious code: School – industry collaboration
- Guidance for schools and businesses collaborating in curriculum-based projects





### 2.3.2 Living lab co-creation practice model

In this section we elaborate on the living lab co-creation practice. Although parts of this practice were already presented and discussed in the White Paper, we include and highlight its main elements in this document for completeness. This section concludes by proposing a practical step-by-step model in the context of SLEs project.

In our White Paper we have discussed in detail how we envision STEAM's inherently integrated and interdisciplinary nature can facilitate the development of innovative ideas and creative solutions that emerge at the interface between disciplines and can involve different societal actors to bring in or link to diverse experiences, needs and problems. We mentioned that it can also involve different learning settings as learning can happen in formal, non-formal and informal spaces, at home, in the community and in activities linked to enterprises.

This naturally leads us to the core element of the open schooling concept which within SLEs is generalized as being an environment that promotes partnerships between different societal actors and the local community with a view to engaging them in the teaching and learning processes but also to promote education as part of local community development. An open schooling learning environment helps and engages learners to apply learning to real-life problems and find effective solutions. They are inspired to be responsive, innovative, and entrepreneurial in their approach to learning, to generate ideas and applying them to solve problems and to create sustainable responses to community's and in general to society's challenges (Price 2013; Covay 2010; Mueller 2015).

Essential elements regarding the creation and establishment of an open schooling environment in school education were firstly developed in the "Open School for Open Societies" (OSOS) EU funded project, implemented between 2017 and 2020 (<https://cordis.europa.eu/project/id/741572>). The project succeeded in introducing and testing an open schooling model with 1000 schools across Europe. The proposed facilitation model is the four-step process "Feel-Imagine-Create-Share", as it was first developed by the "Design for Change" movement and has been accordingly adapted. The main purpose of each step is as follows:

- **Feel:** Students identify problems or challenges in their local communities. They can also select topics related to global challenges that may affect their communities in the future. Students observe problems and try to engage with those who are affected, discuss their thoughts and ideas of solution in groups, and make a plan of action, based on scientific evidence.
- **Imagine:** Students envision and develop creative solutions that can be replicated easily, reach the maximum number of people, generate long-lasting change, and make a quick impact. They are meeting external actors, they are looking for data to support their ideas and they are proposing a series of solutions.
- **Create:** Students are implementing the project and they are interacting with external stakeholders to communicate their findings.
- **Share:** Students share their projects with other schools in the local or wider community.

A representative example of a school project focusing on road safety and its relation to community well-being that was developed based on this generic four-step approach is the following: 1. **Feel:** teachers and students make a survey of their local area and observe that bicycle riders are exposed to increased risk of accident when they need to turn, 2. **Imagine:** they propose a solution that if riders or bicycles are equipped with automatic flashing indicators then the following car drivers will be better alerted to expect a turn, 3. **Students collaborate in groups with the physics, informatics and electronics teachers and design a vest with a wearable device, with tilt or inclination sensor, control unit and led**





lights, that bicycle riders can wear, 4. Students show their creation in school exhibitions and share online their design documents, source code, photos, videos etc. This example demonstrates well some of the core elements of a learning ecology as we envision it in SLE, however it needs to be complemented e.g., to better incorporate the dimension of a partnership where a diverse set of actors are involved in co-design and co-creation of potential solutions.

An enabling methodological practice to either initiate, support, or complement an open schooling learning environment is the concept of Living Lab. In general, “living lab is a diverse partnership driven by innovation methodology for co-creation acting in an environment for co-creation and user engagement” (Millet et al. 2015). In this way Living Lab may simultaneously refer to and encompass three different dimensions: partnership, methodology and environment. As already discussed, a partnership is established and focused on the collaboration of different actors from diverse sectors. In SLEs we aim at having partnerships that comprise actors that include schools, informal educators, local public authority, enterprises, and the end-users themselves, who may be involved as individuals or through a civil society organisation. These actors should commit to engaging the project in a co-creation process.

In addition to partnership, a Living Lab can be defined as a practical methodology to develop innovation through a user-driven process of co-creation. This process emphasizes the central role of the user in the Living Lab approach. Instead of being the target of an innovative solution, the users will be its co-creators, so the solution can be driven by their needs, values, priorities, and ethical concerns. This approach is a real commitment for all involved as they are required to deeply participate into a project and really contribute to its development. The methodology in practice emphasizes the idea of development cycles comprising prototyping, testing, and redesigning phases, in a way that is related to or resembling engineering design processes (see Figure 9).

### Main stages of the Living Lab

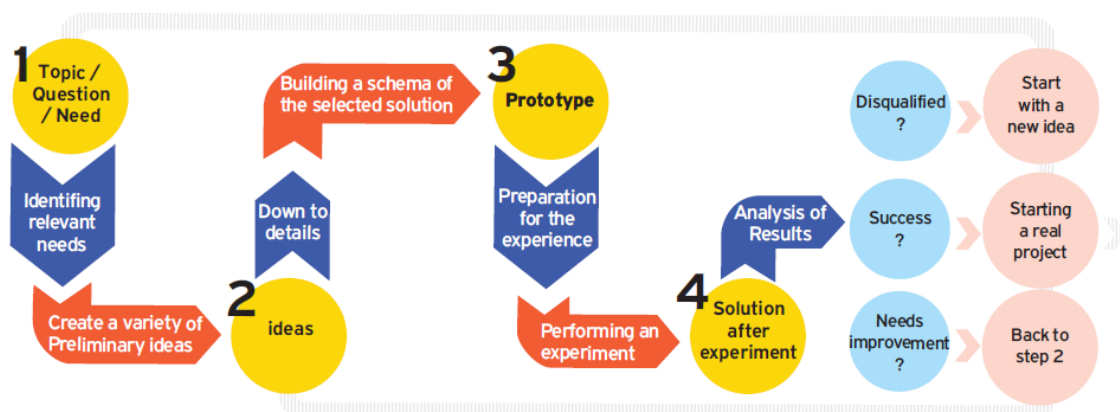


Figure 9 : Main stages of the Living Lab methodology as proposed in SALL project (Aguirre, 2021).

In this framework the key principles and main steps of development of a Living Lab project are:

- Start from a real issue with a goal to study, develop and propose a real solution, making use of the participants’ personal experience. This principle ensures that the project focuses on an





issue and not only on a general idea, and that the main driver of the project will be to look for solutions, and furthermore to have those solutions implemented.

- Actively involve all societal actors in co-creation. Those can be local actors, individuals or institutions that have some common direct or indirect interest with the school, and that are benefited or affected by the process or the project's outcomes.
- Conceptualize, design, and propose solutions using all the perspectives that are present in the partnership, thus maximizing the various levels and types of expertise from different actors. The school students would generally be the core team to generate ideas, but those ideas would have to be discussed, shared, and built with the other actors.
- Aim to put in practice and test early and quickly preliminary solutions with users. By prototyping initial versions of possible solutions, the learning value of a project is coming both from the study of an issue, but also from the transformation of an idea into prototype and the testing with real users.

A living lab approach has been widely implemented throughout the SALL (“Schools as Living Labs”) and GenB (“Informing and educating young people on more sustainable behaviours and choices to build a future generation informed and interested in bioeconomy”) projects in both of which partners of the SLEs consortium participated. Similar to these projects’ practice, we suggest adopting and implement a staged living labs process as follows (Leminen 2012; Millet et al. 2015):

- Co-creation/co-design: This is the ideation stage where participants develop a portfolio of possible ideas that they could implement to reach their desired goals.
- Exploration: at this stage the participants explore the ideas in more detail and together come into a consensus on which ideas they would like to produce and experiment on. In this stage, they develop prototypes of the ideas or bring them to life so that they can deploy them to the target population in the next stage.
- Experimentation: At this stage, the participants test the developed prototypes or products with the target population.
- Evaluation: At the final stage, the participants of the living labs reflect on how their product or products were received by the target population, whether they managed to reach the goals they were intended for and whether any adaptation is required.

An overall synthesis and adaptation of above-mentioned processes in accordance with the generic open schooling model and the living labs practice leads to the following step-by-step model as depicted in Fig.10a. It consists of the main stages of Feel and Imagine as part of the initiation phase, which then lead to the stage of Co-create and its iterative subsequent steps of Explore, Experiment and Evaluate, and finally concludes with the stage of Reflect&Share. visualises better its correspondence and accordance with the overall development process discussed in the previous section.



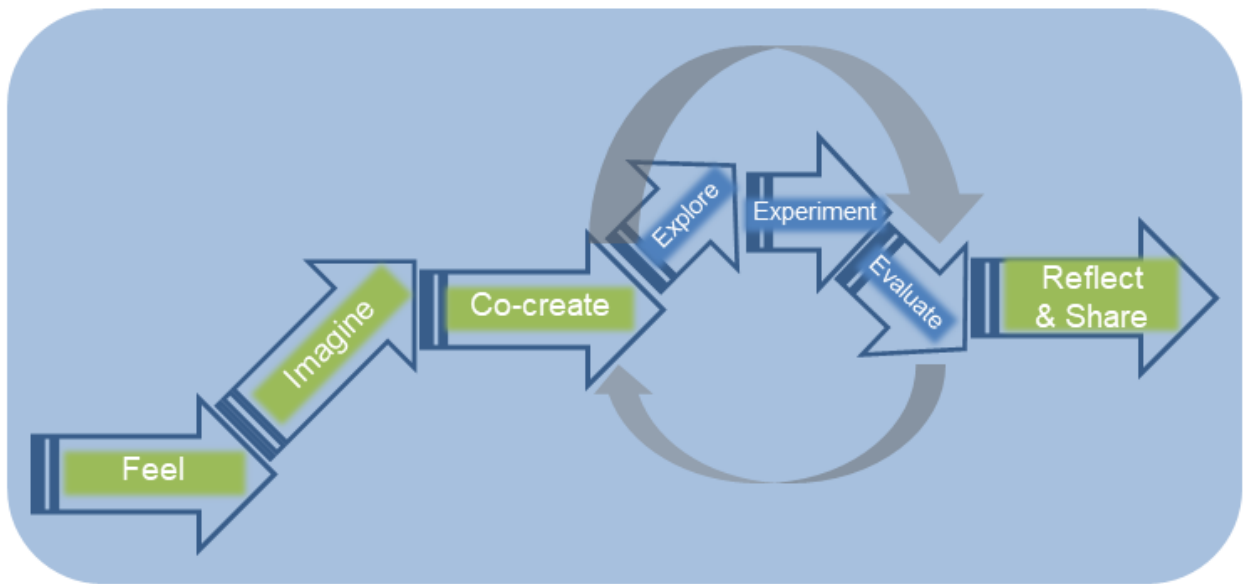


Figure 10a: Main stages of the integrated living lab co-creation practice

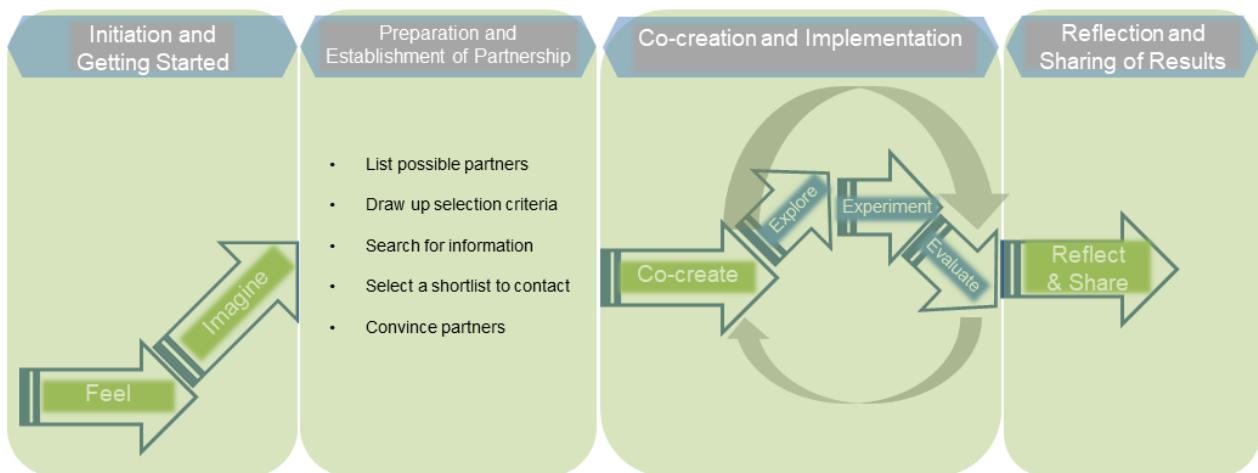


Figure 10b: Main stages of the integrated living lab co-creation practice in accordance with the SLE step-by-step SLE development process

This is the main model we propose to partners, educators, and other stakeholder participants in the SLEs project to adopt and implement during the piloting phase. This initial version will be refined and updated where needed depending on observations, findings and feedback collected. Possible improvements or needed alterations will be consolidated before the start of the mature implementation phase.





In the appendix of this document, we also propose a template to facilitate the process of development and reporting of an SLE or its initial concept and envisaged activities. This can be utilised by partners, schoolteachers, and educators in collaboration with other stakeholders involved to document an example SLE or a complete one developed in partnership. In addition, sharing proto-SLEs or mature ones through a standard template allow others to easily adopt, adapt and replicate them.

### 2.3.3 Guidance on inquiry-based learning

An SLE invokes and encourages the nurtures of pathways as a metaphor for thinking about ways to provide structure to learning experiences, about how they are inter-connected and inter-related and about how they allow or help learners to build upon them to pursue goals requiring extended engagement across multiple contexts and learning opportunities. Further to this, along pathways the living lab practice inherently induces abundant opportunities for investigation and experimentation, i.e., see Explore-Experiment-Evaluate in Figure 10. In other words, scientific inquiry is a core element of an SLE, therefore we adopt a pedagogical framework that greatly encompasses it. The main approach we adopt and suggest is project-oriented inquiry-based methodology for effective teaching and learning.

We emphasise the fact that this focuses on tasks within an SLE so that learners are better guided or supported. For instance, in the example SLE presented in the first section, students can be split in smaller groups to investigate and experiment on various aspects of the design of their drone. For example, how to make an effective heatshield to better protect a sensitive component, or how or which parameters of a propeller affect the overall lift that needs to be generated so that the drone can really fly. These micro-projects can follow an inquiry-based methodology so that better guide learners through the process of postulating a research question, plan an experiment, gather evidence by data collection, analysis and finally conclude to results. The whole procedure does not have to be overwhelming or over constraining, it is up to the teacher or educator or the partners involved to decide how to better implement it or simplify it to better match the learning needs of the students.

One may draw distinctions between project, inquiry or problem-based learning, however in reality the differences are minor. School students and in general learners found them highly engaging because they are conducting work that is meaningful to them and can connect to real life problems and challenges. Learning begins with a problem to be solved, and the problem is posed in such a way that learners need to gain new knowledge before they can solve the problem. Rather than seeking a single correct answer, they interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. The whole process gives many opportunities to connect to real-life and real-world challenges, work across disciplines, learn to function and collaborate in teams, communicate their findings and solutions, engage with their peers, experts and communities.

In the following we first present in detail a generic inquiry-based model based on five phases (Orientation, Conceptualization, Investigation, Conclusion and Discussion) that is suggested for teachers to follow in the design of interdisciplinary educational activities. A variation of this can be also adopted and integrated not only in the structure of STEM related projects but also in the features of creativity focused ones. At the end of this section, we also discuss in brief types of inquiry to better understand how inquiry-based methodology can be adapted in accordance with different levels of learners' self-direction.





### Project and inquiry-based pedagogy

Inquiry-based learning (IBL) is an educational flexible strategy with phases that are often organized in a cycle and divided into subphases with logical connections depending on the context under investigation (Pedaste et al., 2015). This framework entails five general phases (Orientation, Conceptualization, Investigation, Conclusion and Discussion) and seven sub-phases (Questioning, Hypothesis Generation, Exploration, Experimentation, Data Interpretation, Reflection, and Communication). It can be used by teachers in order to conceptualize a structured way to implement inquiry activities and develop multidisciplinary educational projects in their classroom and beyond.

IBL is not a linear procedure (see Figure 11) and learners should be involved with various forms of inquiry, going through different combinations of the phases, not all of them necessarily. For example, if the data analysis is not satisfactory enough, students can return to the conceptualization phase and reconsider their question and/or their experimental design. When students come to a conclusion, new questions can be generated, and the process starts again in a progressive fashion. A description of the processes that each phase encompasses is provided below and the connections between these processes are presented in Figure 11 (Pedaste et al., 2015).

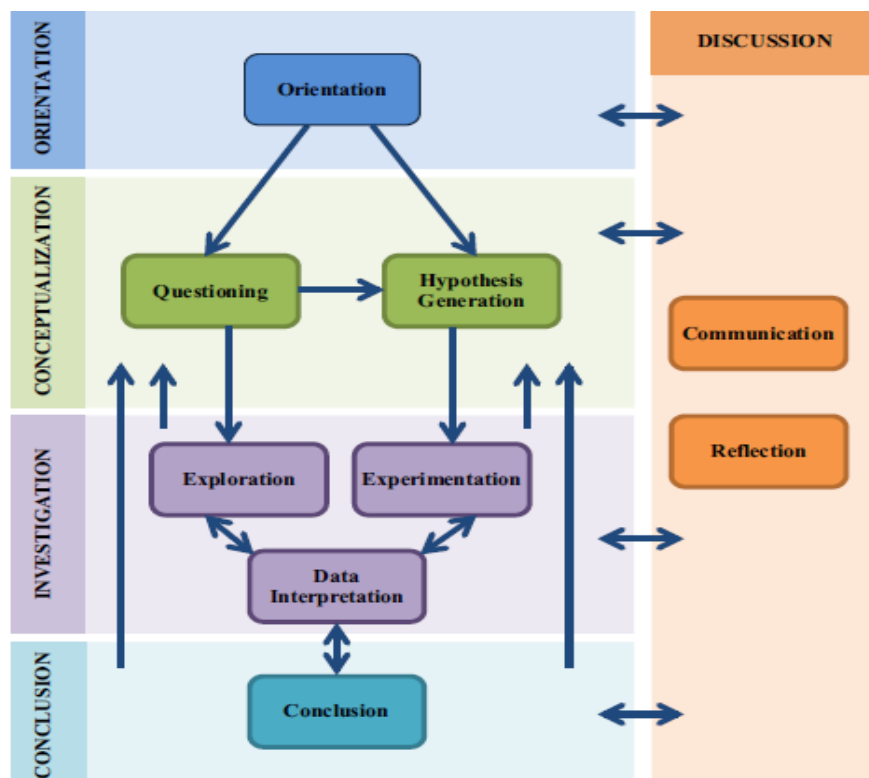


Figure 11 : Phases and subphases of inquiry-based learning and their relations as described in Pedaste et al., 2015







## Phases and subphases of inquiry activities

**Orientation:** Orientation is the phase where the identification of the problem occurs. The topic to be investigated is presented and interest about a problematic situation that can be answered with inquiry is stimulated. The topic under investigation must be relevant to students' daily life, interests, and prior knowledge. The teacher's role in this phase is to encourage students to express ideas, prior knowledge, and questions about the topic, while promoting interaction and communication between them. For example, students can create concept maps of what they know, do not know or want to know about the topic under investigation. These kinds of activities can also be useful for the next phases of inquiry.

**Conceptualization:** Conceptualization refers to the understanding of the concept, which relates to the problematic situation presented in the previous phase. It is divided in two sub phases (questioning and hypothesis generation) that lead the learner to the investigation phase. Now the teacher's role is to help students understand how they can formulate questions and/or hypotheses that can lead to an investigation. If students are not familiar with the questioning and hypothesis generation sub – phases, the teacher can choose a structured type of inquiry at first and then progress in more open types of inquiry in order to provide the appropriate guidance.

- **Questioning subphase:** Questions are formulated in order to design an investigation that produces answers. As this skill is developed through inquiry, students can gradually understand which question can lead to investigation and which one is more generative and might lead to different or richer processes.
- **Hypothesis Generation subphase:** A hypothesis is generated through providing explanations of how the identified variables relate (Pedaste et al., 2015). It explains how and why phenomenon functions based on former experiences and prior knowledge (National Science Foundation, 2000).
- **Investigation:** Investigation is the phase where students collect evidence to answer their questions and/or test their hypothesis (National Science Foundation, 2000) and includes the sub – phases of exploration, experimentation, and data interpretation. The teacher provides materials that the students might need and keeps them on track so that the process they choose to follow is a process that answers the investigative question. Students should determine what constitutes evidence and collect it. If they are not familiar with this process, a structured type of inquiry can be chosen. The teacher can provide or encourage students to create means (e.g., tables, charts etc.) that can help them organize, classify, and analyse the data.
- **Exploration subphase:** Exploration is an open process which generates mostly data concerning the identification of a relation between the variables. It is chosen typically when the question that was formed in the previous phase was generative, because students do not have a specific idea of what to explore or how the identified variables relate to each other (Pedaste et al., 2015).
- **Experimentation subphase:** Experimentation includes the design (e.g., choosing the materials and means to measure) and performing of experiments taking into consideration the variables that need to change, remain constant and be measured. The products of this subphase are data or evidence that can be used later for analysis and interpretation.

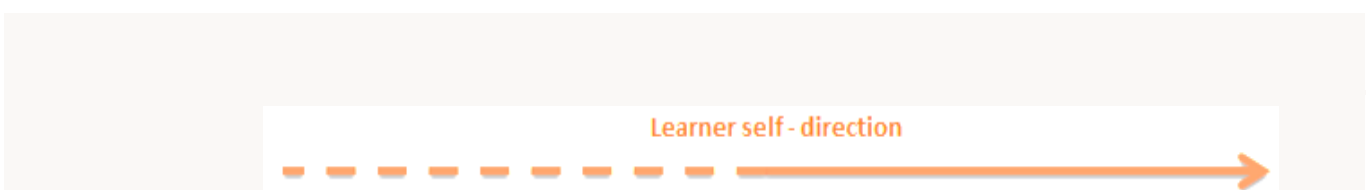




- **Data Interpretation subphase:** According to the National Science Foundation (2000), data interpretation “includes finding a pattern of effects and synthesizing a variety of information” (p. 57). Depending on the concept under investigation and the inquiry procedures that were chosen, finding relations between the variables is sometimes the key for getting the desired outcome (answering the investigative question). Organizing and classifying the data (with graphs, charts, tables, pictures etc.) can benefit this process.
- **Conclusion:** In this phase students draw conclusions based on the investigative question and the interpretation of the data. The teacher’s role during this phase, a comparison between the interpreted data and the predictions and initial ideas (that students expressed during the orientation phase) can be stimulated. This process can also lead to new hypotheses and questions about the topic under investigation (as shown in Figure 11).
- **Discussion:** During the discussion phase students articulate their findings through communicating them to others and/or reflecting upon all or some of the stages of inquiry during the process or by the end of it (Pedaste et al., 2015). The teacher’s role is to encourage collaboration so that students can present their findings and ideas, provide arguments and give feedback to others. If they are not familiar with these practices, the teacher can provide guidelines that will help them to communicate during all the phases of inquiry.
- **Communication subphase:** Communication includes discussion with others and representation of results in a manner that is understandable to all (National Science Foundation, 2000). It can be applied to a single phase or the whole cycle of inquiry and is usually an external process (Pedaste et al., 2015).
- **Reflection subphase:** In this subphase students reflect on their work, their results and the concept under investigation. Reflection can even give rise to new thoughts regarding the inquiry cycle or a single phase.

### Types of inquiry

The types of inquiry vary so that students are actively involved in the process to the extent that they are competent and able to do so. The type of inquiry a teacher may choose to follow is highly depended on the objectives of the lesson, the age of the students, their previous involvement with inquiry and the scientific skills they have already acquired. As shown below in Figure 12, the more responsibility the student has, the less direction is provided and more open the inquiry becomes (National Research Council, 2000).





	Structured	Mixed	Guided	Open
Essential Features				
1. Learner engages in scientifically oriented questions	engages in question provided by teacher, materials, or other source	sharpens or clarifies question provided by teacher, materials, or other source	selects among questions, poses new questions	poses a question
2. Learner gives priority to evidence in responding to questions	given data and told how to analyze	given data and asked to analyze	directed to collect certain data	determines what constitutes evidence and collects it
3. Learner formulates explanations from evidence	provided with evidence and how to use evidence to formulate explanation	given possible ways to use evidence to formulate explanation	guided in process of formulating explanations from evidence	formulates explanation after summarizing evidence
4. Learner connects explanations to scientific knowledge		given possible connections	directed toward areas and sources of scientific knowledge	independently examines other resources and forms the links to explanations
5. Learner communicates and justifies explanations	given steps and procedures for communication	provided broad guidelines to use sharpen communication	coached in development of communication	forms reasonable and logical argument to communicate explanations

Figure 12 : Types of inquiry and their features regarding questions, evidence, explanations, connection of the explanations to scientific knowledge and communication. Adapted from Inquiry and the National Science Education Standards, National Research Council (2000) p. 29

The variations of inquiry types concern the increasing or decreasing involvement of the teacher and student in the process. Structured inquiry is directed from the teacher so that students reach a specific result, whereas in mixed inquiry students are more involved during an investigation with the teacher guidance still being the most dominant. These forms of inquiry usually are chosen when students are





first introduced to inquiry practices and when there is a focus in the development of a specific skill or concept. Open inquiry provides more opportunities for developing scientific skills, given that during open inquiry the students work directly with the materials and practices in a way that resembles authentic scientific approaches (National Research Council, 2000).

For example, if students lack previous experiences with designing investigations and collecting data, a more structured or guided form of inquiry should be chosen. When students acquire the skills needed, they can progress to more open inquiry activities. Students should at some point participate in all the forms of inquiry, while gradually moving from one form of inquiry to another with the simultaneous progression of complexity and self-direction.

## 2.4 Facilitation methodology and guidelines

Although SLEs is not an explicit school-based initiative, nevertheless it highly aims at attracting the participation of schoolteachers and educators from informal and non-formal education providers as key initiators or contributors to a learning ecology. Teachers, and in general educators, develop practices of teaching with which they feel comfortable and confident. When they mature it is usually difficult to change them, or they feel insecure to adopt innovative methodologies, technologies or practices such as the educational approach and activities to be developed and proposed in SLEs. However, when asked in surveys, most teachers express the willingness to adopt new methods and models of teaching that lead their students to better results in terms of concept understanding, content knowledge and behaviour or attitude change. A required condition is that they are thoroughly introduced in practicing these new methods before applying them to their everyday teaching or setting. In this respect, we plan in the SLEs project to offer a comprehensive facilitation programme, encompassing multiple modalities, online or in-person, that include hands-on practice workshops, that will not only help teachers to explore, adopt, implement and improve an already developed learning ecology but also assist them to gain confidence and experience towards developing their own ones themselves individually or in collaboration with peers or partners of the consortium.

Herein we discuss and propose the main design considerations along with general and specific recommendations of features that such a general facilitation programme can incorporate. Partners can further adapt it depending on local needs and circumstances.

### 2.4.1 General recommendations

In general, when developing a learning ecology and considering its educational activities, a facilitation or training programme or a curriculum in partnership it should be emphasized that alongside the process of how an overall learning activity is developed, key aspects of the activity itself like aims, learning outcomes, content, teaching and learning methods and assessment methods also need to be considered. Usually in literature (for example see Plomp 2009 and van den Akker 2007), an extended version of key aspects of an activity, and in general of a curriculum in the broader sense of a learning continuum, is shown in the shape of a spider web, thus metaphorically illustrating that placing additional focus on one of the key aspects this would inevitably influence the shape and the strength of the whole web. The key aspects as depicted in the following figure (Figure 13) are: rationale, aims and objectives, content, learning activities, teacher role, materials and resources, grouping, location, time and assessment. We adopt this spider web model, and we suggest that all these





dimensions should be clearly defined, be in balance and be addressed in the programme. We believe this will strongly assist and facilitate teachers in better embracing the SLEs concept and its objectives.

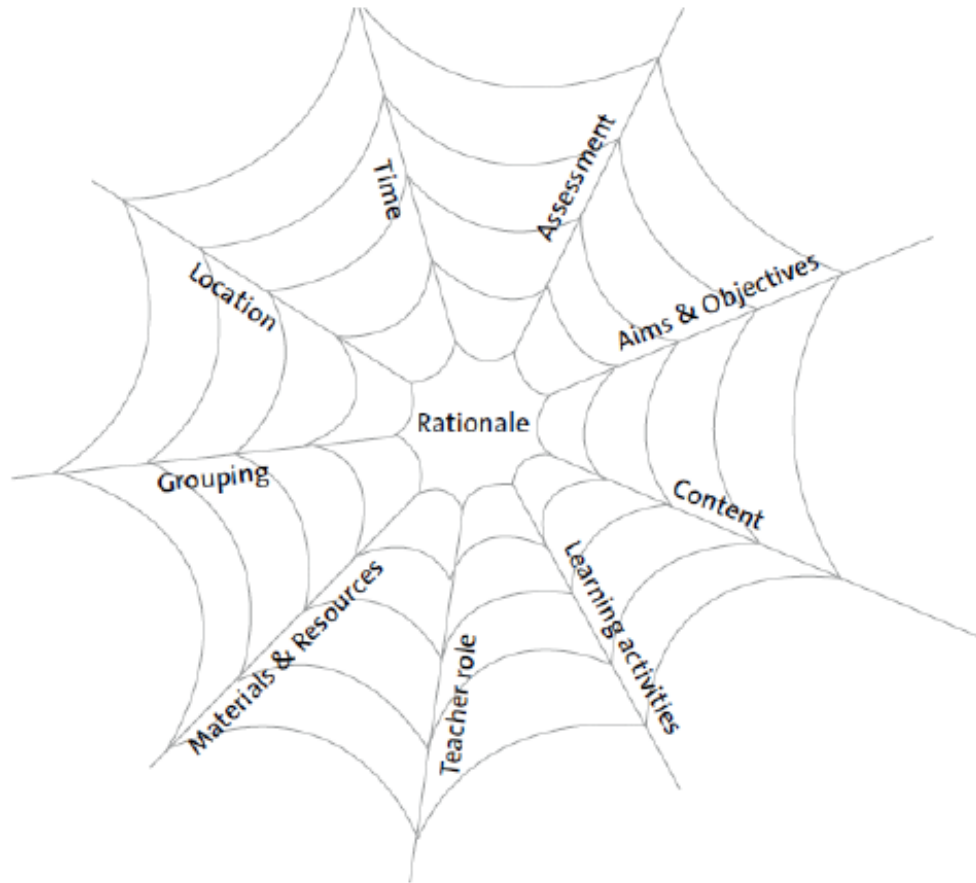


Figure 13 : Curricular spider web as proposed in van den Akker, J. (2007).

Regarding the general process of facilitation, we follow a phased approach where participants are first introduced to an example, they practice it taking the role of learners and analyse it in a reflective and collaborative way. Then, they envisage how to implement it in a real setting, taking the role of action researchers and critical observers, and finally discuss their findings and also collaboratively reflect on the results and outcomes. The whole process is implicitly of iterative nature and provide a well-founded overall framework for progressive and gradual acquisition of, for example, suggested and already-made best-practices to start with or the development of new ones. These phases may not be explicitly imposed or practiced, for example in the mode of separate distinct workshops, but they can be implicitly infused in a single session of a hands-on workshop with different groups working on different aspects that will finally be wrapped-up at the end.

In this context, we recommend offering teachers and other stakeholders dedicated workshops to help them to pre-practice by following examples, develop further and reflect on their practices, their understandings, and past experiences, and collaboratively reflect on the proposed processes and models. These workshops can be offered in parallel or within the framework of existing professional development programs, or even better in synergy with other similar projects and initiatives. They can also be grouped into consecutive cycles in line with the school year schedules in each country where





workshops of training activities are implemented first in a small number of participants, feedback is collected, and findings are shared with other partners in different countries.

In conclusion, in the framework of SLEs and complementary to its main objectives, the facilitation programme is recommended at furnishing, touching upon or strengthening the following general educational objectives:

- To enable primarily teachers but also other stakeholders involved in a SLE trying new ideas in practice as a means of improvement and as a means of increasing knowledge about the curriculum, teaching, and learning opportunities within a SLE.
- To raise their level of critical thinking about teaching and learning, and in general about their everyday practice.
- To engage them in collaborative and reflective implementation and development of SLEs.
- To facilitate the adoption of the SLE concept and approach in teaching and learning.
- To emphasize the importance of sharing experience, expertise and valuable outcomes with other teachers and stakeholders in their community and beyond.
- To empower them in engaging in similar approaches to SLE that affect their communities and well-being and for their particular needs or interests.
- To strengthen their capacity to become educational content creators or opportunity explorers to overcome standard curriculum constraints.

### 2.4.2 Specific recommendations

In the following we list together also a main set of specific features and characteristics that we recommend that such a facilitation programme should emphasise and incorporate.

- Overall inclusive approach. The programme and its activities should attract and involve teachers and educators of all disciplines, levels of experience, gender, social or ethnic backgrounds. Specifically: Gender balance. Training examples, proposed educational activities, projects or ideas should attract the interest of teachers and students of both genders avoiding common stereotypes. Social inclusiveness and integration. Similarly, they should be accessible and attract the interest of teachers or students of social or economic disadvantaged areas or in rural or distant sites.
- Multidisciplinary/interdisciplinary collaborative approach. The programme and its activities should address or involve teachers of multiple scientific fields.
- Modular structure. The programme and its materials should be modular and staged so that it can be followed by teachers with different level of needs, expertise, experience etc.
- Replication potential. The proposed approach, programme and activities should be easily transferable to other European countries.
- Low-threshold use of ICT technologies. Proposed online resources, e-learning platforms or tools should enhance and complement traditional teaching and learning and promote digital literature of both teachers and students without any prerequisites of prior technical knowledge, requirements for pre-installed software packages etc.
- Open and online modes complementary to in-person workshops. This will greatly facilitate the participation of schools and teachers from rural or distant areas thus greatly enhancing the diversity and inclusiveness aspects of the facilitation programme itself but also of the SLEs project overall.





- Scientific and technological correctness. Training modules or accompanying materials, including links to online resources, public video instructions etc, should not create gray areas or matters that may create misconceptions to teachers or students, promote pseudo-science etc.
- Emphasis on experiential aspects, practical hands-on training and do-it-yourself implementation.

### 2.4.3 Facilitation approach

Our facilitation approach aims at being inductive and practical with its participants focusing on gaining a better understanding of a learning practice or achieving a real change or improvement in the practice context. It involves actively participating in a change situation, assisted, or guided by peers, with the aim of improving their strategies, practices, and knowledge of the environments within which they practice. Furthermore, it should be interactive, collaborative, and reflective so that it can enable work with others to propose a new course of action to help their community improve its work practice. Generally training or facilitation by action is a form of development, intervention, and change. In this context, the overall facilitation of change induction can be implemented as a cycle with planning, acting, observing, and reflecting phases wherein educational practices or methods are first developed, then tried-out in real settings and finally are further improved based on reflection of observations and findings.

In the framework of the SLEs project, the development and implementation of pilot and mature SLEs practices, which are then elaborated and evaluated, are planned for the school years of 2023-2024 (i.e., Sep 2023 – Jun 2024) and 2024-2025. During each period, we suggest in total 2+1 workshops to be organized primarily for teachers and educators but also with the inclusion of other stakeholders who will be introduced and guided through the 2 corresponding cycles of implementation. The corresponding guidelines and proposed agendas are described in the following sections. These should be considered as initial versions subject to refinements and improvements to be identified during the pilot implementation period. Updated versions will be documented in the corresponding deliverable D3.2 “Partnership co-creation and facilitation methods and learnings” and D2.3 “The SLEs final framework”.

#### Guidelines for pilot cycle workshops

In the first cycle (pilot implementation), the corresponding first two workshops are suggested to take place during the first half of the school year and preferably soon after or complementary to an initial introductory or open invitation session offered by consortium partners to teachers within the framework of the project.

In the first workshop of the series (Workshop-1) participants mainly are introduced into an example educational activity, discuss, and reflect on its thorough understanding and act as being learners themselves (“participants as learners”) or in other words experience, practice and reflect on a given activity from the learner’s perspective. One of the main objectives of these workshops is also to raise awareness and clarify possible misconceptions, to specify or expand learning objectives, to propose alternative approaches. They will also motivate participant teachers to start developing their own practice or adopt existing ones in collaboration with their fellow teachers.





A workshop of this type may consist of two main sessions. The first session, about 1-1.5 hrs. long, will have presentations of a possible example SLE or related educational activity and short reminders and familiarization with the relevant processes and tasks. This session will open the discussion among the participant teachers so that they reflect on their own understanding but also compare with each other's approaches and views. The second session, about 1-1.5 hrs. long, can be a co-creation practice or group work on a given theme. In this session teachers are asked to identify and discuss strong and weak points, main advantages, and barriers, do clarifications and develop further their understanding and confidence on initiating and implementing similar approach in a real setting. At the end or during the sessions of the workshop participants are encouraged to work collaboratively, to feel free to provide feedback to organizers and to fellow teachers about prior experience, effective approaches, possible challenges, and barriers, etc. The workshop finishes with a round table wrap-up discussion. Below is a proposed agenda for a workshop of this type.

Table 1. Example agenda of Workshop-1 (“participants as learners”).

Time	Session description
9:00 - 10:00	Introduction and welcome (5 min) Presentation of an example SLE or related educational scenario
10:00 - 10:30	Familiarization with model processes and tasks Discussion and reflection
10:30 - 10:45	Break
10:45 - 11:45	Hands-on practice on a proposed activity or group work to develop one on a given theme
11:45 - 12:15	Discussion and reflection
12:15 - 12:45	Wrap-up presentation or round table wrap-up discussion and conclusions

The approach of SLEs incorporates a gradual structure to facilitate change of attitude in parallel to knowledge development. Within this structure, e.g., teachers can reflect on what they know already about, for example, open-schooling living labs or/and inquiry-based teaching and learning methodologies, how they learned or practice them, and what are the achieved results and benefits for the students. Teachers are better able to understand essential aspects of new methods of learning and teaching by discussing and thinking about their adopted instruction practice, and also share their experiences with other teachers. They basically act as critical thinkers, questioning constructively the pros and cons of introducing new learning methods in everyday teaching. They furthermore discuss or propose how certain learning activities may facilitate students' skills and knowledge. These discussions and reflections of teachers as thinkers, soon after they have developed and tried-out an educational activity, can be facilitated in a dedicated practice reflection workshop. This is the main







rationale of the second workshop in this cycle (Workshop-2), which can be entitled “participants as critical thinkers”.

In this workshop participants discuss in deep and reflect on their tried-out or developed practices. They discuss on difficulties they foresee or expect or have experienced and propose workarounds or methods to avoid them. The objective of the workshops of this type is not only to motivate more teachers and newcomers to adopt a new methodology or reflect on it and act as critical thinkers themselves but also to provide them with practical answers and assistance on how to break any last barriers, concerns or fears they have before an actual educational activity can be implemented in their school. Therefore, if possible, more experienced teachers that have already practiced such activities and learning approach in their teaching can be invited in these workshops to present their best-practices and collaboratively reflect on them or to act as role models, mentors and change agents.

A workshop of this type is practically a follow-up and logical sequence of a “participants as learners” workshop and can be organized soon after the first stages of a learning ecology’s pilot implementation have been completed. It may consist of two main sessions. The first session, about 1-1.5 hrs. long, consists of presentations of developed activities around the table on which all participants will reflect on later based on their own experiences and findings so-far. The second session, about 1-1.5 hrs. long, will mainly focus on participant’s discussions about difficulties, identified or expected problematic areas, and proposed solutions for improvement. The workshop finishes with round table wrap-up discussion or presentation. During the sessions of the workshop participants are reminded and encouraged on one hand to be openly reflective and critical on all aspects of their experience and on the other to think and act in a constructive and practical way towards possible improvements or needed alterations. If time permits the organizers may schedule at the end of the workshop an interviewing session with volunteer participants or selected teachers to thoroughly discuss and express their views on STEAM teaching and learning and the approach of SLEs in an open and critical way. Below is a proposed agenda for a workshop of this type.

Table 2. Example agenda of Workshop-2 (“participants as critical thinkers”).

Time	Session description
9:00 - 10:00	Introduction and welcome (5 min) Round table presentations of educational activities
10:00 - 10:30	Discussion and reflection on experiences and findings so-far
10:30 - 10:45	Break and networking
10:45 - 12:15	Discussion on difficulties, identified or expected problematic areas, and proposed solutions/improvements
12:15 - 12:30	Wrap-up

The third workshop (Workshop 3) is suggested to take place during the second half of the school year, and if possible after the end of the piloting phase and before the start of the larger-scale implementation. Participants teachers, educators and other partners involved have now passed from the states of “learners” and “critical thinkers” and are now more reflective practitioners that have





started developing the required skills and they are gaining confidence to assess, evaluate, adopt, but also adapt and redesign and develop further authentic learning activities. They are now more capable or in a position to assess their achieved results and so to reflect on the efficacy of the application of the methods proposed in real settings. The purpose of Workshop-3 is to build on the whole experience so-far of the pilot cycle and continue it in a refined way.

In this context Workshop-3 is similar to Workshop-1 with the addition that participants are now elaborating and reflecting on activities or best-practices that have been developed in different countries (“looking across borders”). After appropriate adaptation, possible replication of similar activities at their schools can be planned or partnerships and collaborations across different countries can be forged. Below is a proposed agenda for a workshop of this type.

Table 3. Example agenda of Workshop-3 (“looking across borders”).

<b>Time</b>	<b>Session description</b>
9:00 - 10:00	Introduction and welcome (5 min) Presentation of activities from different countries
10:00 - 10:30	Discussion and reflection
10:30 - 10:45	Break and networking
10:45 - 11:45	Hands-on practice/co-creation on proposed theme or group work to redesign, improve, expand or develop new ones
11:45 - 12:15	Discussion and reflection
12:15 - 12:45	Wrap-up presentation or round table wrap-up discussion and conclusions

### Guidelines for mature cycle workshops

In the second cycle of the project (mature implementation), the corresponding first two workshops’ scheduling and agendas can be similar to the ones already discussed. However, their scope can be broader in order to mix together more and less experienced teachers. In this context, teachers that have participated in the pilot implementation phase can be encouraged to organise themselves such workshops or assist in inviting, guiding and mentoring less experienced teachers in collaboration with the partners involved.

With respect to the third and final workshop (Workshop-3f) in this cycle, its main focus is the presentation and discussion of outcomes, best-practices and recommendations on the SLEs approach in a holistic way and also, if possible, at policy level. A workshop of this type can have a more official character and can be part of e.g., an annual teachers’ conference or an international event on education. Having an overall concluding nature, it can be organised towards the end of the project. It may consist of a session of invited speakers followed by a session where best-case scenarios teachers or their associated partners present their work and outcomes to colleagues from other countries. The





closing session will focus on proposed next-steps and improvements and policy recommendations along with a critical perspective of the overall approach. Below is a proposed agenda for a workshop of this type.

Table 4. Example agenda of Workshop-3f.

Time	Session description
9:00 - 10:30	Introduction and welcome (5 min) Presentations of success stories, best-practices, and best outcomes
10:30 - 10:45	Break
10:45 - 12:15	Discussion and reflection on lessons learned, outcomes achieved, methodologies practiced, experiences, proposed next steps/future improvements and recommendations
12:15 - 12:30	Closing/Wrap-up

## Summary and outlook

The SLEs Methodology – First Version is the second deliverable of Work Package 2. In this document we have laid out a comprehensive methodological framework of guidelines and proposed actions to enable and guide the development of SLEs in accordance with the main foundational concepts in our White Paper. The work that was presented in this document was based on the outcomes of four co-creation workshops that were organized and coordinated by EA and in which all partners of the consortium participated. The workshops took place during May 2023 (Month 5), each workshop was focused on a particular theme. The themes were: 1. Understanding SLEs concepts and dimensions, 2. Learning by example, analysing an example SLE, 3. Focusing on SLE prototype development and processes, 4. Consolidating overall methodology. The main objectives of this series of workshops were on one hand to bring together all partners' insights, views, ideas, expertise, and experience towards a co-created constructive methodology, and on the other, to simulate and facilitate a similar process of co-creation that each partner can initiate and implement at local level.

Following the same sequence adopted in the co-creation workshops, we started by presenting a representative example of an SLE to clearly illustrate its main elements and objectives and consequently to better understand what a complete SLE entails.

We then discussed our suggested step-by-step development process that can facilitate and guide the development of a generic SLE. The proposed SLE development process is divided in four main steps, which are: 1. Initiation and Getting Started; 2. Preparation and Establishment of Partnership; 3. Co-creation and Implementation; 4. Reflection and Sharing of Results. For each step, we gave a general description, discussed its main objectives, and presented the main actions, conditions or prerequisites needed, supplemented with general recommendations on how to successfully complete it. We also





included a list of key indicative questions to be thoroughly considered or addressed which can assist the successful completion of each step.

To enhance the readability of the document, we finished discussing the whole sequence of proposed steps of development and then proceeded with accompanying sections that complement them by elaborating on certain key aspects based on the synthesis of partners' insights and recommendations derived from the co-creation workshops. On partnership establishment and stakeholder engagement, and on living lab co-creation practice. As co-creation is being a core and very significant element of the SLEs perspective and development process we revisited the open schooling model and the living labs practice as first discussed in our White Paper. We synthesised and adapted their subsequent steps in our generic development process to produce an easy-to-follow elaborated version, which at the same time we believe will be more appealing to learners and in general to partners of an SLE. It consists of the main stages of Feel and Imagine as part of the initiation phase, which then lead to the stage of Co-create and its iterative subsequent steps of Explore, Experiment and Evaluate, and finally concludes with the stage of Reflect&Share. This is the main model process we propose to partners, educators, and other stakeholder participants in the SLEs project to adopt and implement during the piloting phase. This initial version will be refined and updated where needed depending on observations, findings and feedback collected. Possible improvements or needed alterations will be consolidated before the start of the mature implementation phase.

We finished by discussing our facilitation methodology and guidelines. Therein we suggested to plan and offer a comprehensive facilitation programme, encompassing multiple modalities, online or in-person, that include hands-on practice workshops, that will not only help teachers, educators and all actors involved to explore, adopt, implement and improve an already developed learning ecology but also assists them to gain confidence and experience towards developing their own ones individually or in collaboration with other teachers, educators or partners of the consortium. We proposed the main design considerations along with general and specific recommendations of features that such a general facilitation programme can incorporate. Partners can further adapt it depending on local needs and circumstances.

As concluding remark, we would like to emphasize that this 1st version of methodology should go together with the White Paper. It will be put in practice in the piloting phase of SLEs and will be constantly refined and updated where needed. A final version is scheduled to be delivered on Month 34.





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## Appendix – SLE Templates

### SLE development template

General Information	
Title	
Initiator	
Partners	
Brief description of main idea or concept	
Learning objectives	
Age range of learners	
Links to curriculum	
Description	
“Feel”	





Describe here any actions, activities, outcomes related to this stage

“Imagine”

Describe here any actions, activities, outcomes related to this stage

“Co-create”

Describe here any actions, activities, outcomes related to this stage including also details about the substages of Explore-Experiment-Evaluate

Explore

Experiment

Evaluate





“Reflect&Share”

Describe here any actions, activities, outcomes related to this stage

References or additional resources

Mention here any references or additional resources related to this SLE

Appendix

Attach or include here any additional items such as example worksheets, spreadsheets, instructions, web-links to audio-visual materials that accompany the SLE







## SLE concept template

### SLE concept

A STEAM Learning Ecology can be organised in different ways including research, analysis and then the design and testing of a solution to the chosen problem. This work can be organised in activities which can vary in type and duration but also in focus (As an exercise, we ask you to describe only 2 of these activities although in a real SLE design and depending on your focus, you would normally have many more.

Title:

Describe your SLE in brief (basic idea, what real-life problem(s) it aims to solve):

SLE initiator (school/teacher):

Other stakeholders involved in your SLE (i.e., university, industry, informal/non-formal learning provider, non-profit organisation, local authorities etc.) Please note that you will need to involve at least two (2) different stakeholders to your SLE.

Students age:

Learning objectives for students (what you expect your students to achieve in terms of knowledge, competences, skills):

Core subjects (STEM and non-STEM subjects):

### Learning activities envisaged

#### Learning activity 1:

Title:

Short description of the activity:

Type of activity (*i.e., seminar, visit, hands on workshop etc.*):

Duration (in hours):

Curriculum connections (*i.e., subjects/topics covered, skill/competence developed*):





Aims of the activity (*i.e., to improve specific knowledge, a skill/competence etc.*) Locations where the activity will take place (*i.e., classroom, science center, company, nature etc.*):

Roles involved (*i.e., teacher, parent, professional, university professor etc.*):

Engagement with the community (*i.e., other schools/ parents/ academy/ industry/municipality/ small businesses/ community garden/ other*)

Sources & resources to be used (*i.e., links to websites/videos/blogs/activity templates etc.*):

### Learning activity 2:

Title:

Short description of the activity:

Type of activity (*i.e., seminar, visit, hands on workshop etc.*):

Duration (in hours):

Curriculum connections (*i.e., subjects/topics covered, skill/competence developed*):

Aims of the activity (*i.e., to improve specific knowledge, a skill/competence etc.*) Locations where the activity will take place (*i.e., classroom, science center, company, nature etc.*):

Roles involved (*i.e., teacher, parent, professional, university professor etc.*):

Engagement with the community (*i.e., other schools/ parents/ academy/ industry/municipality/ small businesses/ community garden/ other*)

Sources & resources to be used (*i.e., links to websites/videos/blogs/activity templates etc.*):





