SENSE.

SENSE. The New European Roadmap to STEAM Education

D3.4 – Report on Knowledge and Practices for future-making STEAM education in Europe

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Abbreviations and acronyms

Abbreviation or acronym used in this document	Explanation
AR	Augmented Reality
CS	Citizen Science
CSS	Citizen Social Science
DoA	Description of Action
EOC	Educational Outside-the-Classroom
EU	European Union
IBSE	Inquiry Based Science Education
ICT	Information and Communication Technologies
PIC	Profile – Investigate - Create
STEAM	Science, Technology, Engineering, Arts and Mathematics

STEM	Science, Technology, Engineering and Mathematics
NRC	National Research Council
VR	Virtual Reality

Glossary

Terms	Definition used or meaning in the SENSE. project	Reference or source for the definition if applicable
Activity	An activity in education is a distinct and specific task or action undertaken as part of a larger educational practice.	Deliverable 3.4, section 4
Art Practice/Art Intervention	A creative and sensory process encompassing research, exploration, translation, or production. An artistic practice can also be an artistic intervention if it transcends conventional artistic boundaries and deliberately engages with contexts, issues or spaces with the aim of catalysing meaningful impact or provoking critical discourse.	Deliverable 3.2
Citizen Science	The term is commonly used to describe different forms of participation in scientific knowledge production and even to describe various forms of participatory action research and digital volunteerism.	Haklay et al. (2021)
Citizen Social Science	Citizen Social Science combines equal collaboration between	CoAct project webpage

	citizen groups (co-researchers) that are sharing a social concern and academic researchers. Such an approach enables to address pressing social issues from the bottom up, embedded in their social contexts, with robust research methods.	
Learning Companion	A supportive and interactive educational companion, designed to assist learners in their educational journey by providing guidance, resources and personalised feedback. It aims to enhance the learning experience and help individuals achieve their educational goals through adaptive and tailored approaches.	D3.4
Meta-disciplinarity	The term "meta" means to overcome and to preserve. Approach that considers that every discipline is, at the same time, both open and closed.	Morin (1999)
Practice	A STEAM practice in education refers to a comprehensive and systematic approach that includes activities and strategies based on principles used to achieve STEAM educational impact.	D3.4
Reverse Ontology	Teaching logic that progresses from abstract	Description of the Project

	models to procedural applications.	
SENSE. Manifesto	A living document that succinctly articulates the partners' shared principles, values and goals, serving as a guiding framework that unifies members' efforts and communicates their distinctive perspective or transformative vision to a broader audience. This manifesto provides a clear direction that fosters cohesion and resonance within the collective, while signalling its distinctive contribution to STEAM to the larger discourse.	D3.4
STEAM beneficiary	STEAM beneficiaries are individuals or organisations who directly gain advantages from a STEAM-focused initiative as SENSE. They experience direct improvements in learning, skill development or well-being. For instance, students participating in a STEAM education program are beneficiaries as they directly benefit from the enhanced learning experiences and opportunities for creativity and critical thinking.	D3.3
STEAM Stakeholder	STEAM stakeholders encompass a broader range of entities such as students, companies or	D3.3

	policy makers. Each of these groups has distinct interests and roles in the success of a STEAM initiative. For example, educators contribute to the design and delivery of STEAM curricula, while policymakers influence funding and educational policies related to STEAM education.	
Transdisciplinarity	Approach to the world, cognitive schemes that go beyond the disciplines, grasping the complexity of the world.	Morin (1999)

The SENSE. project

There is a widespread understanding that the future of a prosperous and sustainable Europe depends to a large extent on the quality of science education of its citizens. A science-literate society and a skilled workforce are essential for successfully tackling global environmental challenges, making informed use of digital technologies, counteracting disinformation, and critically debunking fake news campaigns. A future-proof Europe needs more young people to take up careers in science related sectors.

Research shows that interest in STEM subjects declines with increasing age. This effect is particularly pronounced among girls and young women; even those of them who take up science studies gradually forfeit their motivation. But despite all image campaigns and efforts to remove the awe of science only “one in five young people graduates from STEM in tertiary education” and only half as many women as men, according to the European Skills Agenda.

The disinterest in science is striking and evokes the question of its causes. Stereotypes and lack of female role models seem to be only a part of the explanation. Nor is there a lack of career prospects that could explain a reorientation despite initial interest.

SENSE. has identified two major problems in current science education that need to be addressed: a) A distorted teaching logic that progresses from abstract models to procedural applications (“reverse ontology”) and b) The inability to implement a learner-centred pedagogy linking students’ everyday knowledge to science-based knowledge, thus promoting motivation, self-directed and life-long learning.

SENSE. advocates for the development of a high-quality future-making education that is equally accessible to all learners and promotes socially conscious and scientifically literate citizens and professionals. SENSE. aims at radically reshaping science education for a future-making society. By promoting the integration of all human senses into exploring and making sense of the world around us we will challenge conventional ideas of science and science education. Considering the pitfalls of current science education practices and the advantages of artistic and aesthetic activity, this innovative approach also considers social inclusion and spatial design as core components for a new STEAM education paradigm. With ‘SENSE.STEAM’ future science learning will be moving away from the standardised classroom shapes and furniture layout entering new learning landscapes.

The project seeks to develop an accessible educational roadmap promoting socially conscious and scientifically literate citizens and professionals. It addresses outdated perceptions of current science education as well as gender stereotypes by integrating the arts, social inclusion and spatial design as its core components. SENSE. will establish 13 ‘STEAM Labs’ across Europe to develop and evaluate the

‘SENSE. approach’ to STEAM subjects alongside students, educators, teachers, businesses and other stakeholders.

The ‘New European Roadmap to STEAM Education’ will take the shape of a STEAM learning companion to support tomorrow’s educators and learners – be it in the classroom, in a museum or on a drilling rig. A digital hub will be established, where practitioners from all ages and backgrounds across Europe will be able to access tried and tested educational practices to increase engagement within these subjects.

The SENSE. consortium

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Executive Summary

This deliverable aims to provide a comprehensive description of the knowledge generated within the SENSE. consortium in the field of STEM and STEAM education, contributing to the identification of the New European Roadmap to STEAM education and to the characterisation of the SENSE. methodology. The report analyses various experiences, insights, and reflections to envision the SENSE. methodology, with the objective of integrating science and the arts on an equal footing in education and to tackle the pitfalls of current practices in STEM education.

The document's structure embodies the journey undertaken to collect and analyse the consortium's knowledge and practices, integrating them with external experiences and outcomes to collaboratively generate valuable insights and reflections essential for the methodology's development. It begins by offering an overview of the STEAM education roadmap of the project, a literature review on STEM and STEAM education, and an examination of relevant European projects in the last 10 years. It then delves into the outcomes of two workshops conducted as part of the project, focusing on areas crucial for innovation in STEM and STEAM education, as well as citizen science and participatory art. These workshops explore phenomenon-based and multi-sensory inquiry education, as well as participatory approaches in citizen science and art intervention. Furthermore, the report presents the findings from the exploration of spatial inquiry and social inclusion, which are identified as foundational issues within the project.

Altogether all the above elements and investigations provide key insights envisioning the transition from STEM to SENSE.STEAM education for defining the project's methodology. The outcome of this extensive work has allowed the development of a working document named the SENSE. Manifesto. This manifesto aims to concisely and pragmatically present both the values and guidelines to be embraced in order to bring the SENSE. project to life. It should be regarded as an open and evolving document, serving as a working tool for reflection and the foundation upon which subsequent components such as activities, workshops, and project tools will be envisioned. Furthermore, the Manifesto has also been utilized as a fresh perspective to examine the array of STEAM practices gathered by the consortium. The resulting reflections have the objective of providing additional insights and new avenues for further exploration. Lastly, these findings offer guidance for envisioning and shaping the forthcoming practices and activities to be developed in WP4.

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1. Introduction

1.1. Purpose of the document

This report aims to map the body of knowledge that exists within the SENSE. consortium, presenting and analysing different experiences, insights and reflections on STEM and STEAM education, citizen science and arts interventions.

It traces the process of developing the characteristic features in the practical design and application of SENSE.STEAM pedagogy. And it provides a final list of SENSE.STEAM activities ready for implementation and evaluation, which will subsequently be carried out in Work Package 4.

All of the work behind this report also feeds into the STEAM Education Roadmap, providing a foundation for the implementation phase and identifying the relationship between current and future STEAM education for the three phases of the Roadmap - Awareness, Action, Advocacy.

1.2. Intended readership

This document serves as a guiding resource, facilitating the reader's access to the valuable insights gained from studying, sharing and analysing STEAM and STEAM pedagogies during the initial year of the SENSE. project. The culmination of these efforts has played a pivotal role in shaping the unique essence of SENSE.STEAM.
All the knowledge we present in this collection is focused on *doing* SENSE.STEAM, based on the understanding that practices are the bridge between theoretical or academic knowledge and sensory phenomena.
In addition, individuals who are engaged as (potential) activists or advocates of the SENSE.STEAM initiative will discover valuable contextual insights to support their efforts in advocating for the integration of SENSE.STEAM within their respective organisations. In this context, we present an in-depth account of the procedural aspects that guided the formulation of an intrinsic value framework. At this point in time, this ecosystem of values, as conceived by the consortium, stands as a fundamental cornerstone of the SENSE.STEAM pedagogical approach, shaping the upcoming stages of the SENSE. project's evolution for the anticipated STEAM labs outlined in Work Package 4 and the consolidation of a Roadmap for future-making STEAM education in Europe.

1.3. Structure of the document

The structure of this document reflects the path taken to gather and analyse the knowledge and practices within the consortium and to articulate them with other experiences and outcomes in order to co-create a set of insights and reflections useful for the development of the SENSE. methodology.

Following this introduction, Chapter 2 presents the starting elements, in particular the characteristics of the STEAM education roadmap and the focal points derived from the literature and a selection of European projects that have addressed similar content. In addition, this chapter presents the analysis and results obtained by the consortium through the sharing of the aesthetic dimension of SENSE., including the implementation of two workshops on the basic elements of SENSE. and the essential elements of citizen science and participatory art.
Chapter 3 takes a further step forward and describes different approaches, feedbacks, questions, and tools that can provide valuable reflections for defining the new approach of SENSE. Finally, chapter 4 describes how the identification of the set of key characteristics and values was achieved and presents the first version of the project Manifesto and some reflection points for envisioning the practices and activities that will be experimented and that constitute the core of the upcoming actions in WP4.

1.4. Acknowledgement

This document is the result of the collective effort and collaboration of several authors and incorporates the valuable contributions of all consortium participants. In particular:

- Lydia Schulze Heuling introduced the concept of a roadmap for STEAM education in SENSE. and extensively edited this report.
- Laura Colucci Gray provided an overview of the latest developments in STEAM education in the literature.
- Carolina Bianchi, Theodoris Kostoulas and Marianna Mitsi analyzed and reported on some of the European projects that served as riflections and inspiration for the SENSE. project.
- Daniela Conti, Anna Krebs, Laura Colucci Gray and Lydia Schulze Heuling organized and reported respectly on the following: a) the foundational aspects of SENSE. discussed in the project's opening workshop, b) the key aspects of Citizen Science and artistic intervention highlighted in the project second workshop, and c) the cultural and aesthetic dimensions in STEAM that inspired the project.
- Explorations of the knowledges on which the SENSE. methodology is grounded were conducted by Florian Theilmann and David Bockstahler (Phenomenon-based STEM education), Laura Colucci Gray (Multi-sensory inquiry), Michael Riebel (Space), and Josep Perelló (Inclusion).

- The inspirations for developing and conducting activities within SENSE. were elaborated by Florian Theilmann and David Bockstahler (PIC process), Daniela Conti (Inquiry-based learning process and moderation techniques), Sasha Brown (Feedbacking techniques), and Lydia Schulze Heuling (Hints for describing and developing new practices).
- David Bockstahler and Daniela Conti presented the co-creative approach used in WP3 to build the SENSE. methodology.
- Daniela Conti and Carolina Bianchi concluded with the presentation of the project's Manifesto and an analysis of key points emerging from the educational practices and characteristics that will guide future explorations of the project.
- The Manifesto of the SENSE. project could not have been developed without the reflections and work of WP3 and without the wealth of practices selected, described, and shared by all the consortium.
- A special acknowledgement goes to Katerina Palaiologou and Josep Perelló for their review of this report.

1.5. Relationship with other deliverables

This report collects and describes the practical knowledge and reflections that have been considered in the development of the SENSE.STEAM methodology pedagogy, which is comprehensively presented in Deliverable D3.5.

Additionally, this report creates links with:

- the results and the considerations elaborated in the two project workshops held in Bergen and Paris, as presented in deliverables D3.1 and D3.2, and the indications,
- the needs and challenges of the beneficiaries of the SENSE. project described in deliverable D3.3,
- the spatial configuration and spatial practices which can facilitate the SENSE. approach and will be developed in work package WP5,
- the preliminary indications for supporting social inclusions which will feed work package WP6,
- the insights for shaping the policy recommendations which are described in D2.7 “Policy brief RP1”
- the consolidation of the final Roadmap to STEAM education (WP7).

2. Background

The SENSE. consortium unites players from formal and informal education institutions, research, businesses, policy makers and NGOs from a wide range of socio-economic and ethnic areas in Europe. The partners cover a whole range of key experiences such as sustainability, digitisation, health, work readiness, gender sensitivity, and life-long learning. The partners combine pioneering STE(A)M

education research, expertise in open schooling and open science, and societal activities with economical, administrative, and professional perspectives.

This vast body of expertise can be placed in various discourses in the field of STEAM and STEAM education and builds on the legacy of previously funded EU projects focusing on the development of new skillsets for scientists across secondary and tertiary sectors to derive natural links and identify applications for synergistic interactions. Synergies and inter-agency work also characterises the core principles of the project's methodology which builds on the body of practical knowledge put together in this document. This collection of practical knowledge of the consortium about STEAM is tailored for their capacity to create synergies between stakeholders and support the dynamic evolution of the project's materials in response to stakeholder needs and accessibility as well as newly emerging needs, fostering innate curiosity and creativity and visionary.

As a truly transdisciplinary approach SENSE. not only provides a new pedagogy and innovative skillsets, but it also pushes the boundaries of disciplinary cultures. Therefore SENSE. includes Citizen science and artistic interventions that are put to the service of teenagers and their parents, students, and teachers, to address STE(A)M-related issues in their communities and to build new educational material that is relevant to their local community and to build new communities at the same time.

Here we describe the processes and the explorations that have been carried out to imagine which features and values should be central to the theoretical and practical foundations of the SENSE.STEAM Methodology, and hence impact the creation of the Roadmap.

2.1. Introducing the concept of a roadmap to STEAM education

SENSE. The New European Roadmap for STEAM Education will provide a step-by-step strategy for awareness, action, and advocacy for STEAM education in Europe.
This Roadmap will be based on a proven methodology - SENSE.STEAM - which aims to introduce a paradigm shift in STEAM education by stimulating learners' self-directed and collaborative learning, supported by a range of digital tools, and empowering all users to design their own STEAM curricula. Therefore, the roadmap will contain a Learning Companion that supports the adoption of SENSE.STEAM through a freely configurable, modular structure, where curriculum content plays on the bandwidth of the senses. In line with the pedagogical approach of SENSE.STEAM, the Learning Companion will be produced as a multimedia output, including textual, visual and audio materials.

Figure 1: The 3 steps plan for creating a roadmap for future-making education in Europe in the frame of SENSE.

The consortium is co-defining and co-creating this Roadmap together with STEAM beneficiaries through the facilitation of dialogue and action. The Roadmap will support STEAM stakeholders and beneficiaries on both, organisational and individual level to develop, implement and communicate their own STEAM ambitions. Three main entry points have been identified: awareness, action and advocacy, corresponding to different 'STEAM maturity levels'.

The Awareness phase is aimed at organisations and individuals who are not yet involved in STEAM, to explain and demonstrate the added value of SENSE.STEAM. The action phase is aimed at those who want to implement STEAM education and are looking for new partners, new practices and want to share their experiences, while the advocacy phase is aimed at stakeholders who are actively disseminating and promoting STEAM. The New European Roadmap for STEAM Education will guide interested organisations and individuals through these phases in an 8-step plan. The following table shows the eight steps that have been defined during the proposal preparation phase, the planned content that will be made available to STEAM beneficiaries to move from one step to the next, and the overall methodology to deliver the planned content.

This deliverable contributes to the methodological underpinning of the educational dimension of the Roadmap.

Steps		Roadmap planned content	Methodology
1	Awareness: What is STEAM education?	Portfolio of STEAM approaches, mapping of Education practices, art practices and citizen science activities related to STEAM	Collection, review and selection through workshops, desk review and implementation and evaluation activities
2	Awareness: What does STEAM education mean for me and my organisation?	Evidence-based information on the added value of STEAM education with real life examples from education, research, and business; assessment tools for stakeholders that enable them to identify implementation strategies and evaluate the impact of SENSE.STEAM	Collection, review, and selection through workshops, desk studies, evaluation of national school curricula and implementation and evaluation activities
3	Awareness: STEAM for a future-making Europe?	Demonstrating added value of STEAM in addressing four societal challenges (Green Deal, Digitisation, Health, Work readiness)	The project will address these four areas explicitly in the implementation phase, and will apply well established frameworks (e.g. DigComp) to monitor the competence growth of participants in the respective area
4	Action: What educational model and pedagogy for STEAM?	A new STEAM methodology, bringing together conceptual, sensorial, and enactive dimensions, called SENSE.STEAM, with four building blocks	A structured display of existing practices, frameworks, inquiry and feedback methods and other knowledge from all disciplines constituting STEAM including research results on effectivity and pitfalls of specific inquiry undertakings and external validation by experts. Enrich this review with tacit knowledge and local understandings of STEAM education as well as policy and practice gaps to identify key elements which have not been considered yet. Finally, ground SENSE.STEAM on the needs of the various target groups (students, business, education providers, etc)
5	Action: How to move from the educational model to practice?	An intuitively to use Learning Companion with demonstrations and a user guide	Co-creation of the learning companion through the implementation activities, and refinement during the two real-world pilot implementations in Norway and Italy
6	Action: How to apply and	Proven strategies specifically addressing different stakeholders	Application of the STEAM educational components in 13 European countries, evaluation of the

	evaluate SENSE.STEAM	showing them how to raise awareness, take action and advocate for STEAM education among their peers.	implementation activities, transforming evaluation tools as self-assessment instruments, development of support tools for implementation guidance and impact measurement
7	Advocacy: How to promote STEAM?	The STEAM Academy and Labs as network and nodes connected via the digital hub, equipped with knowledge, supporting tools and policy recommendations for implementing the STEAM Roadmap, addressing both European Education and European Research Areas	Running STEAM dissemination activities coordinated by our STEAM Labs, deriving policy recommendations and strategies for stakeholders, and tailored to the different target groups
8	Advocacy: How to engage with other STEAM actors?	The STEAM Academy and STEAM Labs as network and nodes connected via the digital hub as part of an open community, supporting networking, knowledge and experience sharing, peer learning, etc.	Expanding the network of STEAM Academy and Laboratories that will support the uptake and sustainability of our Roadmap for STEAM education in Europe, linking with other initiatives, Erasmus+, H2020 and Horizon Europe projects and with the new European Bauhaus initiative; two physical nodes in Norway and Italy as a result of the real-world pilots

Table 1: SENSE.'s 8 steps towards building The New European Roadmap to STEAM Education

2.2. Review of the academic discourse on STEAM education

Over the past 15 years, the European Union has invested heavily in STEAM education projects (see section 2.3) to promote inquiry-based and art-based approaches to develop scientific skillsets and competencies for democratic participation in science and society. To meet these aims, there is a need to rethink the science curriculum to extend beyond traditional academic subjects; to support creativity and engagement of pupils with 'real' science in 'real' world settings linking students' everyday knowledge to science-based knowledge (Hagendijk, Heering, Principe & Dupre, 2020; Schulze Heuling, 2021), and to provide equitable opportunities for all students to participate in their own education.

In this view, STEAM education is proposed as a transdisciplinary endeavour (Costantino, 2018, p.100); a set of practices bringing together sciences and arts to enhance social cohesiveness, build diverse relationships, and promote deeper learning and creative problem-solving (Marshall, 2010).

However, no singular definition exists about the specific disciplines that may be included, nor their particular aim or function, giving rise to different configurations of STEAM, each one with different aims and structural features such as:

- Inclusion of disciplines which may or may not be part of traditional school curricula, such as Engineering (Brophy et al., 2008), with a focus on design-based learning.
- Re-purposing of subjects as conventionally taught in schools by emphasizing applied and economically relevant dimensions, e.g. Design and Technology Education turning into Creative Industries (Brown et al., 2011), with a focus on readiness for work.
- Combination of academic and vocational subjects, such as sciences and the arts in transdisciplinary creative inquiries (Colucci-Gray et al., 2019), with a focus on participation and sustainability.

Specifically, in this project, the interest is in developing a practice that links STEAM practices with an approach to science education that shifts the focus away from abstract models and procedural applications (Dahlin, 2003; Østergaard, 2017) to implement a pedagogy that puts the world and its phenomena at the centre, and enhances the ability of all students to draw on their everyday experiences to encounter the world and themselves (Biesta, 2022). What is crucial here is not just which arts can or cannot be included, but more importantly what these arts can specifically do and how they are positioned in relation to STEM.

In order to generate a basis for developing the praxis, the literature helpfully distinguishes two main approaches, which are informed by different aims and contributions to the creation of collective knowledge:

- Art-infusion. In this assumption, STEAM education focuses on integrating arts into the teaching of STEM subjects, to enhance creativity and motivation (Perignat and Katz-Buonincontro, 2019). This approach views the arts as a tool to serve other subjects, for example by aiding transmission and presentation of factual knowledge, assuming that knowledge can be pre-set, and teachers choose which subjects to use to convey content. The goal is to increase learning outcomes and facilitate access to the curriculum (Perignat and Katz-Buonincontro, 2019, p. 32)

- Art-integration. This approach seeks to promote artistic and scientific inquiry practices on equal terms, by including a broad spectrum of disciplines and material practices (Burnard, Colucci-Gray and Sinha, 2021; Colucci-Gray et al., 2013; Cook et al., 2020) and recognising the creativity that exists in everyday contexts, from painting to cooking from botany to gardening. The approach is rooted in trans-disciplinarity, recognizing the interdependences between multiple levels of the same reality and the inseparability of subject and object (Nicolescu, 2012). In this view, education should emphasize the question of attention and the sensing body as the prime locus of cognition. Freed from the expectation to entertain and deliver to specified results, both arts and sciences

– of whichever kind - are implicated in an event and its performance. Trans-disciplinarity focuses on understanding how knowledge is produced by paying attention to who is involved in the co-creation process, and who is being excluded.

Critical for the developing of the practices in the SENSE. project are the insights especially from the latter approach in which the aims and roles of the arts and the sciences and their relative contribution to the process of creation of collective knowledge are both necessary and acted as indivisible.

2.3. Review of applied STEAM in EU projects

As the aim of this deliverable is to identify projects and practices from which the partners can build a shared vision of SENSE.STEAM, the authors started with an overview analysis of the projects listed in the DoA of the SENSE. project. These projects are STEAM initiatives relevant to SENSE. for different aspects in order to identify opportunities for synergy, to support the engagement strategy and to develop a robust approach for embedding SENSE.STEAM research in European research and education policies.
The authors then made a selection and analysed 10 projects in more detail. The selection criteria were their relevance to SENSE from different perspectives (e.g. the relationship between science and the arts, social inclusion, focus on teacher training, etc.).

The selected projects listed below, funded by the European Union, were selected from a large number of initiatives carried out in Europe over the last decade:

- BLOOM (2017 – 2020). The main objective of this project was to establish open and informed dialogues, co-created by European citizens, the civil society, bioeconomy innovation networks, local research centres, business and industry stakeholders and various levels of government including the European Commission. BLOOM elaborated five hubs (communities of practice) that allowed for an iterative process that involved with all stakeholders through various cycles of value development, enabling cross-fertilization and idea generation through shared knowledge and experiences.

- REGGAE -Enhancing trust in science and promoting STEM (2021). The project team organized activities (hands-on activities, workshops, science shows, science cafés, demonstrations, informal talks with researchers and guided tours) to bring together researchers and citizens. The project's overall goal is to reinforce trust in science and its methods.
- OTTER (2021 - 2024). This project aimed to strengthen educational outside-the-classroom (EOC) networks within Europe, connecting experts from four different regions to be used to carry out a programme of EOC pilot schemes

and analysis of the effect they have on the performance of participating students.

- VERTIGO (2016 - 2020). This project provided a major opportunity to develop more inclusive, intercultural, and thus productive and innovative approaches to the participation of artists in Information and Communication Technologies (ICT) research activities and for promoting synergies between creative arts, businesses, research organizations and the society at general.
- E-STEAM: Equality in Science, Technology, Engineering, Art and Mathematics (2018 – 2021). By adding art into STEM education, the programme sought to relate to more students (with a particular attention for gender equality), and to give them the opportunity to engage in creativity and to express themselves through their projects while tinkering, making, sharing, and playing. It was central to identify women in STEAM areas with a key role in developing scientific and artistic knowledge. The project aimed to:
  - Establish synergies among schools and the labour market towards creative and meaningful engagement of girls in STEAM education (through a mentoring programme).
  - Develop a virtual platform.
  - Exploit and disseminate personalised activities by promoting the use of the platform.
- STEAM4SEN - Erasmus + (2019 – 2022). The project aimed to enhance schools' capacity to provide inclusive and efficient STEAM education to students with special educational needs to enrich their learning experience and employability opportunities in the Industry 5.0 world through the development of educational materials and guidelines for secondary school teachers, managers and students.
- CREATIONS - Developing an Engaging Science Classroom (2015 - 2018). The CREATIONS coordination action aimed to demonstrate innovative approaches and activities that involve teachers and students in Scientific Research through creative ways that are based on Art and focus on the development of effective links and synergies between schools and research infrastructures to spark young people's interest in science and in following scientific careers. CREATIONS established a pan European network of students, teachers, researchers and artists, and involve them in unique learning experiences. Recent discoveries in the field of high-energy physics, astronomy and biology were the focus of the implemented activities.
- MARINE MAMMALS - Using marine mammals for making science education and science careers attractive for young people (2016 - 2019). Marine Mammals proposed to create a European consortium of education and research institutions, alongside small to medium enterprises, to promote STEM subjects and students' interest in science careers. Together with teachers and educational scientists they formed expert groups who developed teacher trainings and summer schools for secondary school students based on state-of-the-art research on marine mammals.

By involving science centres and public aquariums the developed teaching material used for creating outreach materials and activities suitable for audiences of different background and age, utilising current technology to engage a wider audience (e.g., interactive posters, podcasts, social media and 3D animations)

- PERFORM - Participatory Engagement with Scientific and Technological Research through Performance (2015 – 2018). The PERFORM consortium aimed to investigate the effects of the use of innovative science education methods based on performing arts in fostering young peoples' motivations and engagement with science, technology, engineering, and mathematics (STEM) in selected secondary schools in France, Spain and the United Kingdom. PERFORM explored a creative, participatory educational process on STEM by scenic arts with secondary school students, their teachers and early career researchers, actively involved in experiencing science.
- STORIES, Stories of Tomorrow (2017 - 2019). Students Visions on the Future of Space Exploration. The STORIES project aimed to contribute to a dynamic future of children's eBooks evolution by:
  - developing user-friendly interfaces for young students (10-12 years old) to create their own multi-path stories expressing their imagination and creativity.
  - integrating the latest AR, VR and 3D printing technologies to visualize their stories (about life on Mars) in numerous innovative ways. In the heart of this intervention lies the vision for integrated curricula and deeper learning outcomes. STORIES Storytelling Platform is the place for students' artistic expression and scientific inquiry at the same time.

Looking at these projects as a whole, we can identify important themes that resonate with the SENSE. philosophy and that will then help us to build a common set of characteristics and values.
For a more detailed analysis of the projects (in particular their relationship to space, between art and science, and with SENSE.), see also Table 2.

The first point that should be highlighted is the involvement of the projects (BLOOM, OTTER, MARINE MAMMALS) in the theme of environmental sustainability. From the design of labs to fighting plastic waste in OTTER, to the increase of awareness in bioeconomy, central in BLOOM, to the reconnection to marine environment of MARINE MAMMALS. SENSE. project resonates with these projects, in particular in terms of aligning with the European Green Deal initiative. Indeed, the connection with the environment is a central theme for SENSE., and it is worth to highlight how the meaning of this word can be expanded also to the urban context, considering the space that we inhabit as a space in which we have both the responsibility and the ability to act politically as a community. In this context, it will be crucial to incorporate the Citizen Science philosophy and practices to empower the communities and to give them the opportunity to build virtuous synergies to think and act together.
REGGAE is interesting in this context, since it includes local initiatives in different venues (beach, riverbanks, museums) bringing together researchers and citizens to

reinforce trust in science and its methods. The connection to the local context is crucial also in Citizen Science and can be central also to Art Interventions, where for example public art can be an enhancer of reflection or community empowerment. This aspect is relevant to SENSE. since activities should be contextualised to the local scenario to be effective and take social and political peculiarities into account.
Similarly, to REGGAE, the goal to reinforce trust in science is also crucial to SENSE. As BERA Commission pointed out in their review, science should be considered as a wider influence in society, as a value itself, and not specifically connected with economic growth.
These examples lead us also to another key value, present in the projects: the importance of networking. In projects such as BLOOM citizens, the civil society, bioeconomy innovation networks, local research centres, business and industry stakeholders and various levels of government have interacted synergically to create value and open dialogue.
In projects such as VERTIGO, CREATIONS, PERFORM, STORIES, different networks have been established, connecting the research institutes with artists (VERTIGO), schools with scientists and creative authors (STORIES), schools with science communicators and performers (PERFORM, CREATIONS).

Art and science have joined together in different ways, the project PERFORM has a particular relevance in this, since students could explore different performing arts, and explore unusual spaces such as stages and theatres.
In the context of SENSE., networking and interaction will be crucial, both to create fertile environments that are able to go beyond the discipline, and to melt art and science, promoting artistic and scientific inquiry practices on equal terms. Furthermore, the relevance of networking was also highlighted in the stakeholders' interviews described in Deliverable 3.3.
Inclusion was a central theme in projects such as E-STEAM and STEM4SEN, the first one being focused on gender equality and the latter on social inclusion.
The theme of space is interesting, since the physical space is often placed side-by side by the digital one (e.g., STORIES, CREATIONS, VERTIGO). Since one of the themes of SENSE is “Digitalization”, it would be interesting to address the issues linked to the inhabiting of a digital space, exploring the possibilities and the limits of it.
Coming back to physical space, some projects have relevance, such as OTTER (specifically focused on the educational outside-the-classroom - EOC) and MARINE MAMMALS, where summer schools have been organized in connection to the marine environment.

In many projects the teacher training was crucial, and certainly this should also be taken into consideration as a priority target for SENSE., being one of the mayor needs reported from our stakeholders (see deliverable D3.3 “Report on Stakeholder Challenges and Needs for future-making STEAM Education in Europe”). In general, it seems however that in the projects described, there was a link to the school curriculum, it should be discussed when planning the SENSE. Labs whether this aspect should be kept or not, and to which extent.

Considering these reflections altogether, there are some aspects of the SENSE. approach that was already present in different shapes and extents in the selected projects, and it would be important to take this into consideration when designing the STEAM Labs, both as a source of inspiration and as a starting point.

Some features, instead, seem to be linked exquisitely to SENSE. First, the central role of the senses in the exploration of the world and of the scientific phenomena, that also provides the name to the entire project. The contributions from Citizen Science and Art interventions will be crucial in designing activities that generate social inclusion, community empowerment and provide a transdisciplinary context to discover the world, where the relationship between science and art allow to get beyond the discipline, recognizing the wonder of a whole, that we will be able to approach and enjoy with our senses.

PROJECT	SPATIAL CONFIGURATION	ART & SCIENCE	LINKS TO SENSE.
BLOOM	Workshops	There is no direct art involvement	Centrality of co-creation. Creation of a roadmap. Importance of dialogue with stakeholders. Focus on bioeconomy (relevant to green deal). Centrality of teacher training.
REGGAE	Included indoors & outdoors activities is spaces such as a beach, riverbanks, museums	Art & Science performances, details not described	Centrality of the work with space, place and time. It has points in common with Citizen Science.
OTTER	Focus on learning outside the classroom, such as in museums, heritage sites, adventure camps, streets and towns, farms and zoos.	There is no clear reference to the type of art	Importance of incorporating the space into the methodology. It links to green deal.
E-STEAM:	Field trips, classroom and virtual platform	Visual arts, music, language arts	Focus on gender equality. Synergies among schools and the labour market. inquiry-based learning, learner-centred pedagogy, blended learning.
VERTIGO	Brokerage web platform supporting matchmaking between stakeholders of ICT and the Arts.	Visual arts, sound and music, architecture, design. Centrality of creating and nurturing links between arts, science technology in	Inclusivity. It develops the connections between the arts and research.

	Residencies for artists in collaboration with research projects in the field of ICT targeted to innovation	the ICT sector. integration of artists in ICT and R&I projects and promotion of synergy between ICT research, business communities, investors entrepreneurs, and arts.	Collaborations with artists are developed within the project.
STEAM4SEN	The output was an online toolkit, to be used at home and in classroom	Creative sides of Robotics and Tinkering	Strong focus on inclusion. Presence of teacher training with educational kit. Focus on work readiness
CREATIONS	Field trips, virtual visits, schools, web spaces such as games and student generated apps, web fests and hangouts	Science theatre or student generated exhibits	Centrality of networking The final output is a roadmap. Art involvement
MARINE MAMMALS	Summer schools. Outreach in science centres and public aquariums	There is no direct art involvement in the project	Idea to organize events outdoors
PERFORM	Selected secondary schools in France, Spain and UK. Theatres and public space have also been interpreted as novel space for science.	Performing arts (clown based on improvisation theatre in France, stand-up comedy in Spain, and science busking in the UK).	Centrality of participatory educational process as a highly engaging and inclusive educational approach. Focus on arts integration.
STORIES	Storytelling digital platform, that has been tested in real settings in schools in Germany, Greece, Portugal, France, Finland and Japan.	AR, VR, 3D printing. Paintings, models, dioramas and constructions, 3D objects and landscapes, animations, science videos and science theatre plays have been captured and integrated in the form of interactive eBooks.	Expression of creativity, starting from scientific knowledge to reach the world of imaginative and possibility (life on Mars). Integration between art and science. Interesting collaboration with writer of children's books.

Table 2: Analysis of selected EU projects in respect to SENSE.

2.4. Taking ownership of STEAM and preparing the road for SENSE.STEAM

This section takes up themes from the two workshops (HVL, Bergen and Museè du Louvre, Paris) and reflects on how they have been addressed during the SENSE. project and in the development of the methodology. Much of the discussion concerns the cultural dimensions and contexts that already exist around STEAM education. This and other issues were further explored in two project's workshops. The first workshop

took place at HVL in Bergen, Norway. The aim was to identify potential building blocks for STEAM and the activities of the SENSE. project. The second workshop was held in Paris at the Louvre Museum on Citizen Science and Art Practices and set the context of citizen science and explored how citizen science can be combined with art practices. A full description of these workshops can be found in Deliverable 3.1 "Report on the STEAM DNA Workshop" and in Deliverable 3.2 "Report on the Citizen Science and Art-Practices Workshop".

2.4.1. Exploration 1 – experiential and situated knowledge on STEAM education for SENSE.

Embodied cognition is a growing field of interdisciplinary interest. Scholars from arts and education, sociology and neuroscience, biology and philosophy have all engaged in projects that seek to establish links between the lived body, tacit knowledge, learning and social interactions. Unfortunately, many of these dialogues offer exchanges based on traditional academic, i.e., cognitive, and linguistic, exchanges.
In order to share the practical knowledge of the consortium and to access the vast wealth of tacit knowledge, we came together for two workshop sessions, one in November 2022 (STEAM DNA workshop) and one in March 2023 (Citizen Science and Artistic practices).

The STEAM DNA workshop opened the development of the SENSE. methodology and outlined the areas that participants identified as essential and critical to innovate the consolidated deductive teaching paradigm on STEM and STEAM education:

- The pivotal position of art within SENSE.STEAM.
- The fundamental participation of beneficiaries to establish the foundations for stakeholders' challenges and needs.
- The identification of critical features for envisioning effective learning pathways towards future making.

The workshop also addressed the need to overcome the stereotypes that have historically accompanied learning in technology and science curricula, in order to ensure the participation and inclusion of all audiences that are often excluded or have difficulty accessing formal learning opportunities.

Instead of following an epistemological and ontological path aimed at defining a priori what STEAM and STEAM education in SENSE. could encompass, the workshop participants rooted the methodology in their experience, in the transfer and discussion of tacit and experiential knowledge among the participants.

This approach allowed to look at the characteristics of the STEAM approach with new eyes and to break down the rather rigid and mostly linear models already tested in STEM and STEAM education. Rather, it allowed to identify some fundamental issues for the design of educational practices, highlighting the sensitive areas to work on for STEAM education. Figure 2 shows an example of this elicitation process.

The results of the exploration based on participants' experiences and knowledge brought out the need to identify the critical characteristics for STEAM education. They also recognised, at the same time, the centrality and the uniqueness of the starting context where needs and voices of participants and the potentialities of a particular situation can situate the educational intervention. In other words, it is not possible to define an educational model that is defined and definitive and proposes consequential steps suitable for every learning situation.

On the contrary, from the practices and knowledge which participants shared during the workshop, an ecosystem of relations emerged to which our attention as educators and experts in the field of education must be attuned. In this ecosystem, it was recognised:

- Knowledge production is not seen as a process of cumulative addition but rather as a craft process, integrating the lived body, mind and context in the learning process.
- Creativity and active participation should be enhanced.
- Sensual experiences and attentiveness should be included.
- Individual and collective learning, linked to real life and phenomena should be promoted.
- The role of the A in STEAM is crucial and it goes far beyond the idea of STEAM as the conventional interpretation of STEM + Art. In this configuration, STEAM is nothing, but the addition of disciplines and the Arts play a subsidiary role to the transmission of scientific subjects. On the contrary, the educational practice we are seeking in SENSE. doesn't rely on artistic devices to raise interest, engender curiosity, help visualise and retain an otherwise abstract scientific and technological content. The A in SENSE.STEAM rather suggests releasing the potential of making, of inquiring through our senses and our body and of the capacity for action and attention. In this sense the A in STEAM arises at the intersection of disciplines to catalyse their potential to learn but also to unlearn; to redraw the contours of given knowledge and be open to imagine as well as to describe. A deepen reflection on this point can be found at chapter 2.4.3
- Learning is a continuum process that cannot be generalised. It starts in a specific situation between individuals who bring experiences, knowledge, perspectives and needs and in a context of unique spatial possibilities and community resources. It also displays feedbacks, recursive loops, and non-linear interactions. It is necessary to tune into these dimensions each time, to analyse the settings and set up adequate tools and approaches.

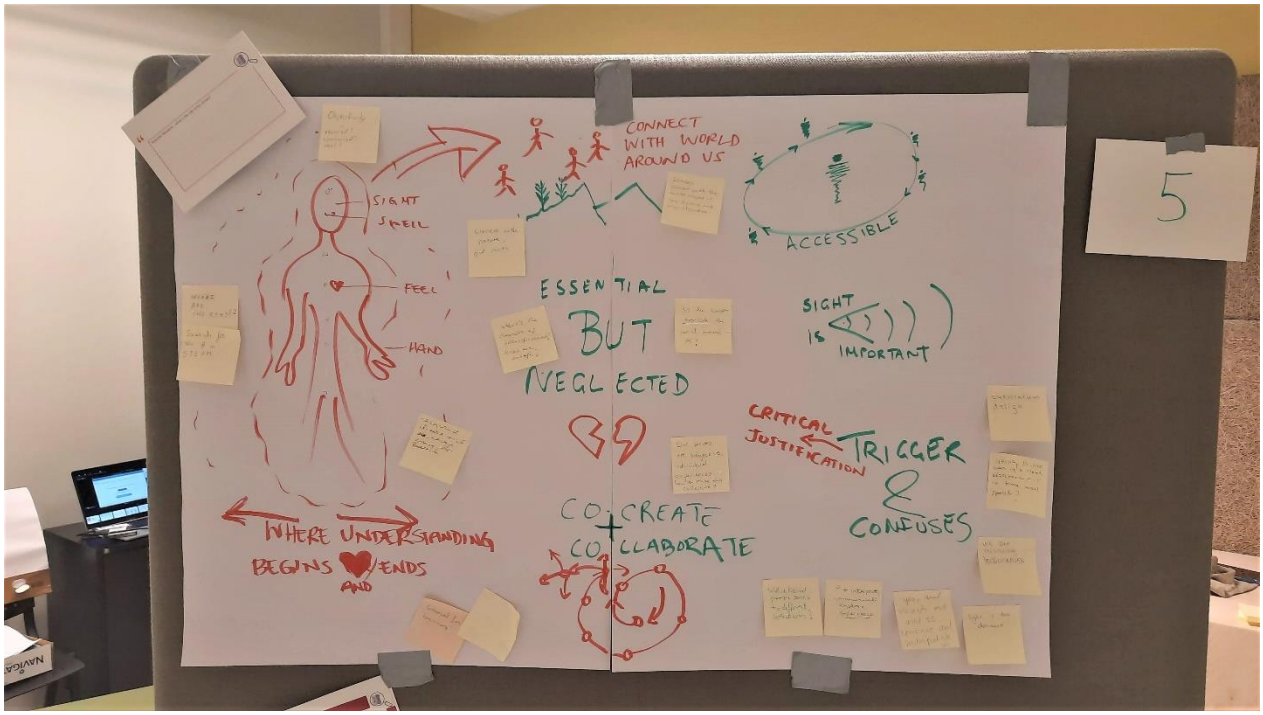


Figure 2: example of intermediate results from the co-creation process on SENSE.STEAM during the Bergen workshop.

2.4.2. Exploration 2 – Considerations from Citizen Science and art practices

As part of the process of articulating the SENSE.STEAM methodology, the second workshop entitled 'Citizen Science and Art-Practices into Action' was held at the Louvre Museum (Fig. 3). The workshop was structured around two main orientations: to establish the context and conditions for participants to actively engage in Citizen Science (CS) as a group co-produced knowledge process, and to explore the potential for convergence between citizen science and art practices through the implementation of four field research activities within the Louvre.

The focus of the workshop was to provide participants with the skills, knowledge and tools needed to develop a Citizen Science project. The workshop linked Citizen Science and arts-related practices, with a particular focus on the notion of participation and embodiment, to ensure that the promotion of Citizen Science and artistic and creative considerations are sufficiently recognised in the SENSE.STEAM methodology. Another aim of the workshop was to develop strategies and tools for collaboration between the partners in conducting research, in order to prepare and enrich the upcoming STEAM Labs methodologies among the different partners.
The research-in-the-field proposal was organised around four thematic axes inspired by a selection of artistic projects and experiences in which participation, the importance of embodied knowledge and the key role of the senses, in the specific context of the space, the museum, strongly marked by the primacy of visuality and

ocular-centrism. From this thematic approach, a series of tools and methodological strategies closely linked to Citizen Science research practices were used.

The workshop created the conditions to discuss and engage in a critical reflection on the general approach of the workshop and on the proposed experience. This discussion was also the occasion for the participants to reflect on possible applications of the workshop experience in the framework of their different local contexts. In addition, this session functioned as a platform for exchange on some important methodological, epistemological, and logistical issues affecting the development of the SENSE. project. As some participants pointed out, the workshop functioned as a great test-case to address key issues for the SENSE. context and to collectively formulate a series of reflections that respond to different levels of analysis:

- On the relationships between the arts and social inclusion.
- On the question of effective diversity and social inclusion in the framework of the project.
- On the relationship between space and the senses.
- On the conception of space as a relational set of interactions.
- On the nature and processes of participatory research.
- On the stakes of the decrease in the degree of disruptiveness in science, innovation, and education.
- On the reductionist power of the museum, as a predominantly visual context, to affect and dictate bodily behaviour and on the preconceptions and value judgements on visitors' behaviour.
- On the experiential and movement-related dimension of the museum visit to enhance its sensory aspect.
- On the effects of sound environments and atmospheres on the visitor's experience in the museum.
- On the importance of materiality, touch and haptic in both knowledge production processes and aesthetic experiences.

The workshop allowed the following actions to be addressed, which are key points in the development of the SENSE.STEAM methodological approach:

- Reflect about how Citizen Science can be related to a variety of educational contexts to change the way we approach STEM, and the way we understand and run a scientific research project.
- Reflect on the implementation of Citizen Science and Art Practices in local contexts.
- Build spaces of interaction among the workshop participants, allowing the participants to collect and experiment Citizen Science strategies that might be valuable to the SENSE. project partners and their communities.
- Set the conditions to the consortium and associated partners to further reflect on Citizen Science and Art Practices in a proactive manner.
- Explore and contribute to the essence of the theoretical and practical foundations of SENSE.STEAM.

Figure 3: The consortium In Louvre for establishing the context and conditions for participants to actively engage with Citizen Science and art intervention approaches.

2.4.3. Exploration 3 - Cultural and aesthetic dimensions in STEAM

The SENSE. project exists within the large context of ongoing development and growing emphasis on STEAM education in Europe. While the acronym is relatively new, many of the ideas behind STEAM initiatives are not and may connect to different theoretical traditions in education. For example, there are STEAM practices in the literature which emphasise practical experimentation in science as well as in art; others which focus on creativity and design and others which include cognitive dimensions of creativity and higher-order thinking (BERA Commission, 2017). In this section, we look specifically at the distinctive contribution of the SENSE. Project taking on the task of creating a “Roadmap for STEAM Education”.

One of the key debates within the consortium has been around the role of the letter 'A' in STEAM. Figure 4 shows a visualisation of some of the findings from this discussion. During these debates, various interpretations of the acronymic letter have been proposed, including "art", "attentiveness", "aesthetics", and other notions of

non-linear thinking and intuition. The (almost) traditional definition of "art" as "creative practice" or "artistic research" provided useful starting points, but often the discussion was dominated (and slightly plagued) by stereotypes that juxtaposed the openness and freedom of artistic expression of "art" with a supposedly limited world of STEM subjects described as technical, closed, over-determined, too linear, etc. In retrospect, the discussion created stereotypical contradictions that are not necessarily helpful or true in practice.

There was a general feeling that this 'fundamental' discussion was relevant and necessary. However, framing the debate within the acronym STEAM ironically divided the participants. The practices that an acronym such as STEAM seeks to unite are already more united than can be described by an acronym that divides these practices, especially when attempting to ascribe specific additional characteristics to one of the 'letters' of the acronym. In this document of knowledge and practices, therefore, the authors deliberately do not attempt to provide a positive definition of STEAM, understood as a collection of disciplines, each with a specific domain of units of measurement and methods that define their mutual boundaries. Rather, the attempt is to avoid any further demarcation, opting instead for a series of suggestions and possible directions for elaborating a much broader conception of what STEAM might mean within SENSE. Approach that explores the possibilities of integrating different ways of knowing. Boundaries are not set, but questioned. And as the SENSE. project progresses, this fundamental debate will continue, bringing in elements of real-life experience from the implementation of practices across the consortium, in order to work together to establish the epistemological foundations of SENSE.STEAM.

This way of understanding STEAM as an umbrella term affording dialogue instead of separation across the disciplines is enabled by a conscious effort to move away from understanding the ‘A’ in STEAM as ‘Art’ as generally defined. Drawing on the work of Dieter Mersch (Mersch, 2015), we approach the ‘A’ in STEAM as the opportunity to open up space for engaging with the epistemologies of aesthetics, thus casting light on the premises for the validity and justification of aesthetic ‘knowledge’. This shift in perspective is introduced here not as an attempt to displace scientific inquiry as commonly conceived but to integrate aesthetic forms of knowing and inquiring as a fundamental way of knowing based on sensorial perception and as such, bringing forth the dimension of human experience as it is often neglected in science education practice.

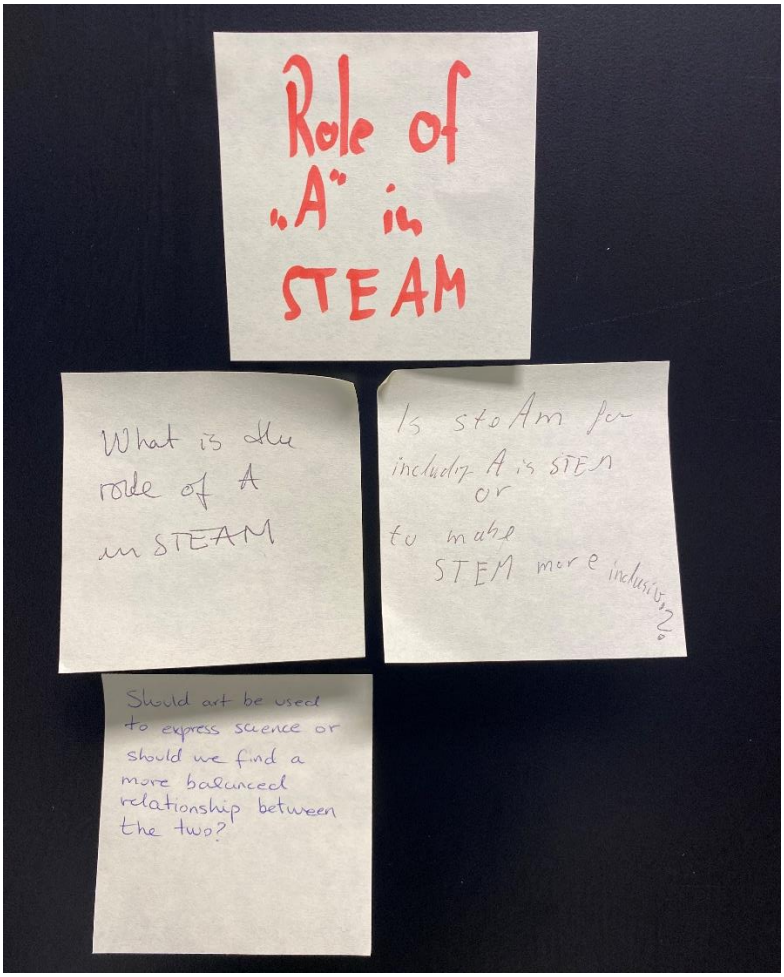


Figure 4: the role of A in STEAM explored by the consortium.

This way, the aesthetic dimension gives space to tacit knowledge as key element in the processes of knowledge creation and as a counter concept to propositional knowledge and causal reasoning. In contrast to propositional knowledge, which is shared through language or mathematical formulae, tacit forms of knowledge become accessible when seen through action.

To this regard, a discussion of a SENSE. conception of aesthetic/artistic knowledge should carefully attempt to avoid any parallelism with existing conceptions of aesthetics, as well as their transference to new territory. Instead as Mersch (Mersch, 2015) advises, the paradoxical formulation of *'another thought' that is simultaneously 'other than thought'* (as concept or discourse) should be followed. This precept aims to reveal the systematic irreconcilability of aesthetic research and scientific research and, what is more, between art and science, and even between art and philosophy. And yet, it is such irreconcilability that would enable integration: not by assimilation of one into the other but through 'difference'; that is, by means of allowing participants to shift perspective and modality of knowing, as well as holding together multiple points of view.

Specifically, while emphasis in scientific research is often placed on defining the focus of inquiry and its boundaries; the work of art reveals itself in the form of those practices that 'work in the work', that is, in the 'becoming' of the processes themselves. Artistic research that engages the body and the senses is aimed at fuelling the research process itself, of enhancing one's art, in researching the details of the experience, rather than being research about or on something. For this reason, we speak of *thought as praxis and as performance*.

2.4.4. Summary

In integrating experiential and situated knowledges, citizen science and art practices as well as aesthetic thought in our project, we propose a scheme that is critical in four ways:

- First, we aim to transform the classical concept of knowledge, by moving from a focus on disciplinary concepts and their definition, to an approach that emphasises subjective and collective embodied experiences. This approach does not presume to define what is expected to be found in the research or what is expected to be learnt; rather, it is an approach that aims to interrupt expectations; displace habits of thought and encourages experimentation via taking on different points of view. Consequently,
- Second, adress neglected methodological aspects of traditional training and education: Instead of a rather static, coherent and linearised picture of scientific research and knowledge that is conveyed in scientific papers and presentations (the further away from the origin of research, the more linear, Fleck 1935/1980), co-creation and ambiguity of knowledges are emphasised and made explicit. Therefore, aspects inherent to the social and situational nature of knowledge creation and implicit forms of knowledge (Polanyi, 1966) are carved out.
- Third, we aim to foreground those practices which draw out the experimental potential of aesthetic knowing; for example, the opportunity to dramatise in a public space or to experiment with soil or water in a public park are a means to engender that shift of perspective we are seeking. The process of aesthetic research as sensorial inquiry and the way it is mediated via the different art-forms is the prime objective This is entirely different from trying to produce or make art and to get people to interpret its symbolic meanings.

These discussions on the nature of STEAM, aesthetics, and art in the context of SENSE., the SENSE. methodology and SENSE. practices have undergone much work within the workshops and beyond and will continue throughout the life of the project.

3. Creating SENSE.STEAM

The ambition of the SENSE. project is to make a significant contribution to STEAM education in Europe and to drive paradigmatically new ways of learning and teaching, by elaborating a future-making pedagogy whereby science and art come together to

create future-making education, support students' ability to ask questions, develop empathy and critical thinking, and make learning meaningful. This process allowed for weaving and making connections among various insights described in other projects and in the literature on STEM and STEAM education, Citizen Science and artistic interventions with the knowledge and concrete experiences that come from the practices and the expertise of all members of the SENSE. consortium. The resulting weft facilitated further exploration of novel avenues enabling the delineation of the framework in which the pedagogy of the SENSE. project can be brought into focus. The insights from these paths are described in this Chapter 3.

3.1. From STEAM to SENSE.STEAM

Considering the pitfalls and the limitations of current science education practices – such as the perpetuation of gender stereotypes, unequal participation, lack of inclusivity-, phenomenon-based and multi-sensory inquiry education, participatory approaches which can embed spatial inquiry and social inclusion in its core were the considered threads from which to start to envision the passage from STEM to SENSE.STEAM.

3.1.1. Phenomenon based STEM education

The integration of STEM with aesthetics is a fundamental aspect of phenomenological educational approaches. With reference to scholars such as Ranciere or Baumgarten, we want to understand "aesthetics" as a regime in which "sensible experience" can occur, and thus go beyond the understanding of aesthetics that describe what art is, what kind of cognition it stimulates, how it differs from nature or from useful objects made by craftsmen.

The philosopher Johan Gottlieb Baumgarten who, in the eighteenth century, elaborated the field of *aesthetics* as a philosophy allowing insights from sensual experiences to a certainty close to the one provided by *logics*. In philosophical tradition (e.g., Kantianism), sensual experience of *phenomena* was seen as defective regarding the 'true nature' of things, that scientific effort would have to address.
Johann Wolfgang von Goethe conversely thought that making sense from and of nature equates to learning nature's language. Nature makes (*facta* = "something that is made") certain offers that can all be perceived through senses; thus, the sensual experiences carry meaning – meaning, which science has to conceive and disclose.

The point of origin for *empirical phenomena* is the common experience that "is as it is" and can neither be true nor false. By describing and qualifying empirical phenomena and making them motive for questions as well as reason for investigation, in science we typically systematically tailor them into *scientific phenomena*. Through observation and experiments – Goethe suggested extensive variation and comparison – one discovers aspects of the respective phenomenon. This leads to familiarity, proceeds to anticipation, and (in best case) concludes in understanding.

The permanent review and readjustment because of the growing experience finally leads to the *pure phenomenon*: an individual (!) totality of previous results, integrating all investigations. In conclusion, science is no longer considered a universal narrative but part of individual biographies. Agreements are still possible as the nature itself induces the existence of appropriate sensory organs and humans' methods ensure that the mediated (by senses) experiences reveal the lawfulness of nature. The empirical and scientific phenomena are experientable while the pure phenomenon refines the experiences into a systematic totality of relations, dependencies, conditions, and configurations of appearances. By arising from experiments and aiming at valid insights, Goethe's method can be thought as a true phenomenology.

Martin Wagenschein (1896-1988) used carefully designed staged situations as *expositions* of science as an integral part of his learner centred methodology *Genetic Learning,* confronting learners with something impressive, strange, or surprising enough to induce an urge for thorough investigation. Similar to today's science centres, the aim was not only to garner interest but also raise specific questions, demonstrate vital aspects, and catch through the actuality or intellectuality while often abstaining from certain equipment. The phenomena are preferably "natural" or built around common objects, thus providing a biographical component. These features together with the unique character of realization of a problem or question and a thorough array loaded with (possibly transdisciplinary) meaning, define phenomena within a STE(A)M teaching environment as a sensual/intellectual experience that is starting point, content, and motivation – all in one. Further, the phenomenon is the guarantee of maintaining the connection between learning environment and real world, which is important for both its relevance and the motivation. A very interesting example of how art and science are deeply connected and able to grasp the *zeitgeist* of their time, and to connect the art and the science worlds can be found in Shearer's (1997 and 1998) reading of famous scientist Jules-Henri Poincaré's book Science et méthode (1908). The famous term "ready-made" became popular by Marcel Duchamp as a new way to face creativity and as new understanding of an artistic object during 1920s. Interestingly, Poincaré used the same term "ready-made" (tout-fait, in French) a lot before Duchamp to talk about his way of working, thinking and researching as a scientist. When he was a student, he didn't take notes. When he studied in his office, he did not seat down and he could lead to carry out several tasks at the same time. He explained that new ideas come to him, appearing at the most unlikely moments. [1]

[1] According to Poincaré, a tout-fait is a working hypothesis, the state of matter of a longer creative process. The whole creative mechanism is developed as follows. First, as initial conditions in a conscious stage, the researchers figure the intention of the research and the laws of nature accepted until then. Second, one critical look at nature disintegrates the laws and their configured discourses to understand the world and then, like gas molecules, broken concepts collide, linking and forming new combinations. Third, a sieve of the unconscious chooses the right combination of concepts. This last stage sets up the right combination of concepts and turns the chaotic gas of concepts into solid ideas. Recombination can happen at any time. Similarly to this process of breaking and then recombine the elements in new combinations, Shearer (1997 and 1998) argues that the Duchamp's ready-mades are not objects found by chance. They are apparitions, visions, novel recombination of his thoughts with

Modern science centre's use these effects: sensual experiences in and around scientific phenomena or experiments are offered to activate visitors and stimulate their curiosity. The topics are not just systematically arranged but displayed as a dynamic field of encounters with nature where interaction with exhibits (and even other visitors or staff) is vital. The milestones of those centres' development were the foundation of the *Urania* institution in Berlin (1888), Kükelhaus' *Erfahrungsfeld zur Entfaltung der Sinne* ("field of experiences for unfolding of the senses") on Montreal's EXPO exhibition in 1969, and the opening of Oppenheimer's *Exploratorium* in San Francisco (1969). Former and today's science centre's aim on both education and participation. Modern science centres have drawn inspiration from these experiences to create interactive environments where visitors can explore the world through science, art, perception and partcipatory interventions. The type of experiences developed in this museums and centres has also influenced their design to create dynamic spaces where exhibits, expositions, experiments, art interventions, events can coexist to promote active participation of visitors. In this context, the practices and experiences developed by the European network of science centres and museums (Ecsite) are of interest for the SENSE. project. Ecsite connects member institutions (more than 300 organisations and 50 countries, among them there is also one member of the SENSE. consortium, the VilVite science centre in Figure 4) through projects and activities and facilitates the exchange of ideas and practices to foster creativity and critical thinking in society, emboldening citizens to engage with science and society issues. However, it should not stay unmentioned that the science centre pedagogy is also subject to critique, for example in terms of hidden curriculum and scripted interaction with the exhibits (Schulze Heuling, 2019; Achiam and Holmegaard 2017).

which he insists on a merely mental art. They become provisional fruits of Duchamp's research as an artist. From this perspective, he argues that even "*Le Grand Verre*" can be considered a ready-made, describing all the machinery of the creative processes.

Figure 5: the VilVite science centre in Norway. Vilvite will host one of the STEAM labs envisioned in WP4 of the SENSE. project.

The undoubted usefulness and relationship of phenomenon-based approaches for the SENSE. project, especially for the practices we envision, lays in the transdisciplinary applicability of phenomena that not only serve as bait to arouse interest (e.g., science centres, Wagenschein pedagogy), but also extensively include and use sensual experiences while legitimating sense-based approaches as actual science. Furthermore, as Baumgarten states, the participation of learners is key to distinct mere sensual impressions from a phenomenon worth investigating. The exhibition character is both relevant for imagining specific activities as well as considering appropriate collaborations or locations. Finally, the thorough installations of experiments plus the participative, sensual experience are meant to foster motivation and positively affect learning outcomes. Regardless, the alignment/combination/integration of STEM and A – aesthetics or whatever it stands for – is a vital constituent of the phenomenological approaches without being artificially added.

3.1.2. Multi-sensory inquiry

Returning to the work of Johann Wolfgang von Goethe, the question of the senses as means of knowing emphasises the value of human experience; and specifically, the importance of learning how to intensify, and tune this experience, as well as recognise that observers are not all equal in their ability and modality to see (Anderson, 2019).

To this regard, education and training are not tasked with making the educational experience the same for everyone but to encourage each person to develop their own perceptual powers through approaches and methodologies that are practice-based. In other words, if we situate the natural phenomenon at the centre of inquiry, then the human is not the agent or the force acting upon the phenomenon but an instrument that can be tuned and adjusted to the multiple and different qualities of the phenomenon. And this requires sustained practice.

Importantly, this is a stance that applies equally to both the arts and the sciences. For example, the speculative tendencies of science can be disciplined through a mode of cultivated observation as disciplined as the subjective tendencies in art. This stance applied to the realm of scientific inquiry implies a belief that there is no separation between the artist and the scientist; their differences being largely about modalities of knowing and sensing, and that such knowing and sensing have repercussion on the observer himself/herself. In other words, there is a reflexive arch or feedback acting upon the individual over the course of their sensing of the phenomenon; feedback that can be affective, cognitive, perceptual and fundamentally, relational. This idea proved controversial at the time of Goethe but has found renovated interest and attention in recent contributions from neuroscience on embodied cognition.

Recent contributions from research on learning and cognition across a diverse array of discipline areas, such as philosophy, psychology, linguistics, neuroscience, and computer science, have challenged traditional cognitivist accounts of the mind (Shapiro, 2011). The view that is emerging instead is known as embodied cognition, which can range in form from a weak embodied cognition through to a more radical embodiment known as enactivism (e.g. Shapiro & Stoltz, 2019). Enactivist origins can be traced to the work of Varela, Thompson and Rosch (Varela et al.,1991) arguing against the idea of cognition as mental problem solving, involving representations in the head, and rather emerging from processes distributed across brain, body and the environment. According to this view, cognition is grounded in our bodily movements (embodied action) and that adaptation to our environment has emerged from and resulted into a cognitive system that is enacted through 'structural coupling' of organism and context (for an extended account, see Colucci-Gray and Gray, 2022).

While classical cognitive science directed its attention towards internal mechanisms (individualised focus), the enactivist view of cognition lays emphasis on movement, with the idea that the sensory-motor apparatus structure our perceptions of the world (Gallagher and Lindgren, 2015). In other words, what 'enters' our field of perception literally depends on 'what we can do' in that field of action-perception. The well-known work of Lakoff and Johnson (Lakoff and Johnson, 1980) illustrated the role of basic bodily movements and gestures (e.g., stepping forward; moving back; pointing to) in the formation of abstract concepts expressed through metaphors. Roth (Roth, 2007) provides an example of such principles translated in engineering teaching practice by showing how "the work-related (hand, body) movements that build and manipulate artefacts, or sensing (hand) movements deployed during an investigation, later function as symbolic movements" (p. 257). And in a similar vein,

the field of mathematics education has taken an embodied cognition stance towards learning by recognising the link between abstract thinking and physical gestures (Duijzer et al., 2019). Communication is thus interwoven with doing, employed for the purpose of doing engineering design more so than being about the subject. This is so because, for example:

> *When I describe a circle with my hand on a piece of paper ... my body ... comes into a state fully identical with the form of the circle outside my body, into a state of real action in the form of a circle" (Il'enkov, 1977, p. 69, original emphasis).*

From an embodied/enactivist stance, the most abstract concepts and tasks do not make sense when they are detached from their ground in human movement and embodiment. As such, the body is also part of our system of memory, a memory that is connected to place and space as the environment in which the body is coordinated with via all the senses. The tactility of the hand for example, is not simply a means to detect information in a reality out there (as the cognitivists would have it) but it is an expression of the organism as embedded and wired into the flesh of the world. Though our senses of smell, touch, sight, hearing, posture we are thus able to gain information about the environment and about our own different modalities of perceiving.

From a practical and educational point of view, it is thus crucial to return to Goethe's message about the body as an instrument; and specifically, the ways in which the body and its sensorial apparatus pay attention to phenomena; what is the nature and quality of such attention. Referring to the specific example of math, Pallasmaa (Pallasmaa, 2009) makes an interesting observation about the body and the hand and how they produce distinctly different ideas than the head. While the latter tends to be conceptual, intellectual and geometricised thinking, the former usually projects spontaneity, sensuality and intimacy. Arts and Sciences in this regard can be seen as repertoires of ways of seeing and of paying attention to the world. They both engage head, hand and body not in the manner of a detached curiosity but as a way of responding and attending to the world and its demands. In this view, particular art-forms such as drawing may be incorporated science to generate a different quality of attention which is more attuned to form, pattern, proportions and shape. Most importantly, drawing gives insight, an insight into how we see the world. Similarly, counting in art may be a way to dis-habitute the viewer from the perception of colour and form, in order to emphasise rhythmic patterns or combinations of characteristics. Also space can be used effectively to re-orient movement and consequentially, perception. Tuning organs of perception through practice-based methodologies will thus be a practical endeavour focussed on the artistry of dis-habituating the ways in which we see and perceive, sharpening and re-directing focus or accentuating our sensorial capabilities to feel, "measure and register the pulse of lived reality" (Pallasmaa, 2009, p. 117).

3.1.3. Space as integral part

Space is never neutral, always personal. Any configuration of the environment impacts human behaviour and vice versa – human behaviour constantly adapts to the environment. In Deliverable 3.5 - the SENSE. Methodology (Chapter 3.2.1), Gibson's environmental model together with the term "affordances" is further discussed, which he devised to capture how beings dynamically interact with the physical world around them. (Gibson, 2015). The concept of affordances has been widely adopted by designers and architects as it offers an elegant way to attribute agency to the created form: design can make the world a better place. However, it is worth reiterating that affordances do not simply describe objective characteristics of an environment which trigger fully predictable behaviour patterns. For Gibson, affordances encapsulate the mutual relationship of the individuum with the physical world, offering a range of actions depending on personal disposition. A chair, for example, provides an opportunity to sit. However, if the actor, for example, is a child, they might use it as an improvised toy.

This simple example should highlight the following points:

- An affordance offers choice. A person will not necessarily sit on every chair they find.
- The action opportunity is relative to the individual disposition of the actor. A child uses a chair for playing and a grown-up for sitting, an artist might use it for an installation, and many people use chairs to replace a ladder.
- The concept allows for a high level of openness. It might be predictable that a chair is used for sitting, but that does not dictate what its user will do while sitting. However, certain backrest shapes can favour sleeping, reading, or eating.

This way, "affordances" amalgamate physical conditions, subjective choice, and individual disposition into a complex, non-determined model of individuum-environment interaction. It allocates agency to both the physical world and the individuum without ending up in a mechanical, behaviourist model.

While the basic principle might appear simple, combining many affordances can quickly add to complex patterns. Certain arrangements of chairs in relation to desks, for example, in a classroom, can greatly influence students' behaviour, how they relate to the teacher and how successful knowledge is acquired (Tobia et al., 2022).

With a move towards learner-centredness and less formal pedagogy, school design responded with spatial arrangements offering a broad spectrum of layered affordances – away from the canonical classroom from a space of control towards a space of opportunities (Gislason, 2011). A large open layout offers a variety of action choices, and a good designer can differentiate spaces in a way that stipulates multiple layers of activities running in parallel. Finland, for example, is moving the spatial blueprint for their schools away from traditional classroom layouts towards new, more open models, involving a large group of specialists to enable usability and bring

out the full potential of spatial complexity (O'Sullivan, 2017; "Saunalahti School / VERSTAS Architects," 2013).

Figure 6: Space as an exploratory environment (Rebecca Horn, Finger Gloves 1972)

It seems to be self-evident that a school that aligns itself with the SENSE.STEAM values involving, making, imagining, co-production and an open mindset will incorporate more spatial openness than the traditional school. The typical STEAM space tends to be a multi-purpose, open-plan space with flexible furnishing to enable many different activities. If a space offers multiple choices of action and interaction, it empowers students to take ownership and engage deeper with their peers and interests, leading to better learning outcomes (Nair, 2014).

This is, however, not an automatism. Students have to learn – or better: to discover - how to actively choose and engage with a space. Increased affordance complexity also means more sensorial ambiguity. Affordances are a two-way street: they offer action opportunities but must be decoded first. This process cannot be predicted and depends on the disposition of the participants. Every student perceives differently and copes with environments in a unique way. Educationalists, therefore, often criticise open-plan arrangements in schools as favouring students who are more capable of embracing the ambiguity and sensory complexity of this kind of spatial environment. Students, for example, with neurodivergent conditions, can suffer in

open plan spaces due to sensory overload. This problem is becoming more evident in other open-plan environments, such as office spaces.

With that in mind, it is too simple to assume that a specific spatial environment is naturally better suited for STEAM, as it ignores the relational nature of affordance theory, i.e., individual character and disposition of each student.

In D3.5 we further discuss the four categories or better lenses which help to structure the design and analysis of the physical environment:

- Function: What are the needs of the people using the space?
- Appearance: What kind of emotions does the environment evoke?
- Environmental Conditions: Light, temperature, smell, air, noise.
- Space: What is the spatial configuration around the users?

Each of these four categories describes the impact of the environment through a specific focus. It goes without saying that all four aspects are inseparably intertwined. However, the differentiation offers a discursive route into a deeper understanding of how educational space works and what it offers to people inhabiting it. The four categories are, therefore, not meant as headings of four "how-to" chapters with simple normative rules. Their purpose is to structure a set of targeted questions regarding the physical shape of the environment, i.e., a guide to critical reflection by everyone involved in the STEAM experience.
For example, suppose the aim is to create a STEAM environment that stimulates the students to "MAKE", "IMAGINE", and "COPRODUCE" in an "INCLUSIVE" environment. In that case, the teachers/instructors should run through each of the four categories and identify key requirements to achieve the educational target:

- What tools are required? Do I need an area that can get dirty? Do I need movable chairs? (..)
- What does the space look like, what colour, round and organic shapes etc? (..) What do I want to achieve with this? Calm people down or energise them?
- What kind of light do we need, can it be a bit colder, are we close to the nature, and can the actors see and smell water? Is noise an issue?
- Is it a high space to encourage larger works? Is combining all participants in one room good for inspiring each other? Where can the outcome be exhibited so everyone can see it?
- Do I have neurodiverse participants, and should I provide a more sheltered space to be more inclusive with participants who struggle with sensory and social overload?

Using those four lenses to identify key affordances will help set preferences and optimise the space to the needs of the participants.
Ideally, those environmental settings and assumptions should also be discussed with the participants after and before the STEAM practice, who, in return, will become more confident in taking ownership of the space and embracing its full potential. In the next step, students could, for example, be encouraged to alter the affordances

and actively work with space, place and time, thus changing the environment into an explorative tool. In fact, the result of the learning experience might not be the experience itself but the understanding of how the place is embedded in the result. Understanding complexity is an important element of STEAM education.

3.1.4. Social inclusion as integral part

"The social is not a part of reality that can be separated off in any meaningful way; instead, it is a principle of connection, association and relationship." (Gross, 2010)

In education, "inclusion is regarded as an extension of a comprehensive approach to education, in which children's rights and social justice are positioned at the forefront of educational thinking; one that goes beyond tolerance and compensating for pupils' perceived 'disabilities'" (Winzer, 2009, p. 183). Inclusion therefore encompasses the idea of recognising and appreciating diverse perspectives and contributions (Winzer 2009).

Social inclusion is an important guiding principle in the SENSE. model. This guiding principle asks for a constant self-reflection process for anyone involved. As organizers or facilitators of a specific activity, it is important to permanently question who is involved in the planned activities and who is not involved. Who is present and who is not. Who is talking and who is not. And finally, give as many opportunities as possible to specific persons or groups or communities which may have more difficulties to be involved in SENSE. activities for a wide variety of cultural, social, or economic reasons (gender included). The effort might require considering different and diverse manners for their involvement.

Also, it can be necessary to directly intervene to rebalance the inherent power relations within a group (for instance, deal with gendered roles inside a group) or among different groups involved in the same activity (for instance, give the voice to these presumably not experts on a certain topic). For this reason, as organizer or facilitator it is also important to adopt an active listening attitude towards all participants' during the development of the activities. The social inclusion guiding principle then asks when necessary to dynamically react and quickly revise the planned activities so that it can be necessary to adopt design thinking, codesign or cocreation strategies. Therefore, the activities should be ready to take an adaptive attitude along their efforts while having in mind that there is no one-fits-all solution.

There is also an increasing effort in scientific knowledge production to address the so-called ethics of inclusion in any scientific practice (Strauss, White & Bierer, 2021). Such practices are imagining partnerships with communities and social groups and the perspective taken directly links with the idea of recognising and appreciating diverse perspectives and contributions. However, this recognition is being seen not as a rigid and static position as it rather conceives a position in a more conversational format. This approach sees social inclusion as the reason to start talking about knowledge co-production as described in Fig. 7.

Figure 7: Key inclusion elements in a CS project (see also [CoAct project webpage](#))

As an example, in the theme of Health, the INVOLVE UK health-research advisory group states: "*A project that is co-produced is one in which researchers, practitioners and the public together share power and responsibility for the work throughout. The 'whys' of this process are self-evident: patients and the public have the right to be more than just participants in research, and their involvement can lead to better outcomes*." (Hickey et al., 2018). This joint effort very often is linked with the understanding of knowledge production as participatory research effort where everyone can take different outcomes and the same knowledge co-production can be seen as a very flexible but transformative learning process.

In this sense, Citizen Science practices might be of relevance. Easy-to-access technologies or low-cost sensors can be a tool to further develop joint research in a crowd-sourced manner which is of interest by a group of citizens which are in a vulnerable situation and their demands are not attended. Citizen Science can then make the knowledge actionable, with several important social implications.

This is the case of xAire project. It represented a large-scale monthly air quality monitoring in Barcelona. It is an unprecedented citizen science project that involves public schools and families to both collect new geographically accurate data on air quality, and to empower themselves to present them rigorously in front of the City Council. The monitoring took the form of an intergenerational citizen science project which counts on the participation of primary school students who install the diffusion tubes with the help of their mothers, fathers, and teachers. The project allowed participants to self-reflect and collectively reflect about pollution on their streets and has been part of the citizen movement to improve air quality in Barcelona.

In the citizen science (CS) broadest extension, CS can be seen as transdisciplinary research blending expertise and knowledge from a wide diversity of participants. It is of particular interest in SENSE. the so-called Citizen social science which can be described as it reads in the CoAct project webpage: "*Citizen Social Science combines equal collaboration between citizen groups (co-researchers) that are sharing a social concern and academic researchers. Such an approach enables to address pressing*

social issues from the bottom up, embedded in their social contexts, with robust research methods. We aim to co-create socially robust knowledge." It is perhaps the most extended form of citizen science (linked to what is also been called extreme citizen science). In social terms, there are also plenty of opportunities to give participants space to contribute to any topic by sharing their lived experience. For instance, this is the case of co-researchers in a project about social support networks in mental health called CoAct for Mental Health. Personal and lived stories written by persons with mental health were the starting point to further learn about the mechanisms, the actors, the contexts in which this social support can take place.

This case of CoAct for Mental Health blends practices and dissolves disciplines as the joint effort is fully motivated by a shared concern as presented by several authors (Irwin, 1995; Latour, 2008) and where research takes the form of collective and public experiments (Latour and Porter, 2004; Callon et al., 2011). The CoAct case points to the fact it is often necessary to intensively work with specific communities and in later phases make it public and imagine other actions that involves society at large. Such an effort can combat stigma and inequities and can find in the SENSE. activities a way to promote social inclusion, social justice and diversity. The discourse also applies to how gender issues can be faced inside SENSE. where it is not only about having more girls in science but also incorporate newest ways to understand feminism and intersectionality.

Along similar paths, to further enhance the experiential dimension, the connection between citizen science and artistic practices can become extremely valuable under the umbrella of social inclusion as a cross-cutting issue. It is possible to mention the efforts made in the context of museum and art exhibitions. However, it is also relevant to incorporate the approaches take by some artists that they understand their own artistic practices under the logics and understanding of what a research process is.

Again, just as example, the artist Antoni Abad devoted his activity to undertaking the megafone.net online communication projects based on publications from smartphones done by various groups at risk of exclusion in Brazil, Canada, Colombia, Costa Rica, Mexico, Spain, Switzerland, United States, and the Algerian Sahara. It started with BARCELONA*accessible. 40 disabled people photographed with mobile phones every obstacle they find on the streets. They draw the cartography of inaccessible Barcelona and located 3,593 sites that they cannot access.
In October 2014 he began developing the BlindWiki set of projects in Rome, an online citizen network conceived for people with visual impairments.

There are two projects that are worth to be mentioned, since they are CS projects that were part of different editions of the Venice Biennale, one of the main cultural institutions in the world, devoted to the promotion of the newest art trends.
These projects demonstrate how the borders between art and science fade, putting at the centre of this shared field the concepts of space, social inclusion and architecture/art.

- 'La Venezia che non si vede. Unveiling the Unseen' is a project by Antoni Abad and curated by Mery Cuesta and Roc Parés, that participated in the 57th Art Exhibition of the Venice Biennale. As part of the already mentioned BlindWiki set of projects, Antoni Abad proposes here a sensorial interpretation of urban space of Venice in collaboration with a local group of blind and visually impaired people. A photo from the project is here reported in Fig. 8.
- CATALONIA IN VENICE – AIR/ARIA/AIRE was a Collateral Event of the Biennale Architettura 2021, and an exhibition curated by architect Olga Subirós. The project reflected upon the central theme of the Biennale, 'How will we live together?', with an investigation into air as a common asset upon which our survival depends. The Catalan exhibition offered an immersion into the radical experience of air contamination through a large, multisensory installation. In this case, the xAire project was invited to be replicated in Barcelona and in Venice with the active participation of students of Architecture. Data and discussions related were part of AIR exhibition.

Figure 8: "Catalonia in Venice 2017_La Venezia che non si vede" by irllull is licensed under CC BY 2.0. To view a copy of this license, visit https://creativecommons.org/licenses/by/2.0/?ref=openverse.

The presence of these projects in the Venice Biennales, and the fact that they are curated by both scientists and artists and architects opens to a transdisciplinary or meta-disciplinary approach, that is able to grasp the complexity of the world and suggests a new way to approach contemporary issues and challenges, that should necessarily be addressed from different points of view.

Recommendations for Social Inclusion
The following measures are key strategies to achieve the aim of inclusion and they will be targeted throughout the project's lifecycle.

Intervention designs therefore aim to include the following elements:

- Inclusiveness is asking to constantly reflect whether there are groups or individuals that are left behind or aside in the planned activities.
- Horizontality is carefully considered balancing power and sharing responsibility with all participants.
- Equity is another important value since efforts and resources are planned to be equitably distributed among participants and all these efforts are planned to be carefully acknowledged.
- Trust needs to be carefully among participants. Specific activities might be necessary to create strong links among participants and a good and if necessary informal atmosphere to freely express themselves.
- Respect is a fundamental value that needs to be strongly promoted along the project activities. All participants must feel themselves safe in a non-judgmental atmosphere.
- Open Science principles are keys in the knowledge production of the project. All materials, datasets and results are planned to be openly accessible under CC licenses. Accessibility must be taken in its widest understanding creating the right materials with the right format to each of the audiences.
- Co-ownership is planned to be considered in all different outputs of the project and based on the efforts of all engaged participants. They are going to be considered co-owners of materials and results collectively generated and invited to contribute as co-authors of the resulting (scientific) publications. Specific protocols must be built under the Creative Commons licensing framework adopted by the consortia.
- Empowerment is an important approach that should run throughout all phases of research projects. During the activities, participants should develop more power to act and explore options for action for their respective concerns.
- Reflexivity accompanies us throughout the entire process related to Steam Labs activities. Our own actions and attitudes should be regularly questioned regarding hierarchies, reproduction of discriminatory behaviour and inclusiveness.
- Reciprocity is a fundamental attitude, especially with underserved groups. The effort to plan and implement activities needs to include time resource to carefully correspond to the dedicated efforts of the participants.

3.2. Structural instruments for planning and conducting SENSE.STEAM activities

Within the collective knowledge of the consortium, we found a rich body of general strategies which can be understood as instruments that provide a structure or

scaffold for the planning and implementation of a SENSE.STEAM activity, regardless of specific content.
In the following sections we present five strategies that can either support the actual conduction of a SENSE.STEAM activity (PIC process, facilitation techniques) or the development of an activity on a topic or question of choice.

3.2.1. PIC process

It is a common conception that science is about certain results, i.e., *insights* or *facts* about the physical world – and that science (and analogously STEM) teaching would consist in teaching these facts and thus creating scientific knowledge. In conclusion, a STEM curriculum would consist in facts amounting to different content of the discipline. Regardless, modern curricula reconsider science as being not only about the facts, concepts, models, or formular but also about the *process* of gaining insight – thus viewing both knowledge and processual competences as important. In this context, STEM educators use the term *inquiry* to point out a multistep process similar to scientific research. In exposed problems or questions, students hypothesise, devise or choose tools (mainly experiments) for examination and eventually use them to verify or falsify the hypotheses. The pandemic in recent years showed us, how fast the distinction between layman and experts is unworldly, while going beyond static notions of "facts" is important to deal with complex reality. In order to be debatable, scientific evidence has to be accompanied by a transparent representation of the argument that led to its acceptance.
The PIC process wants to enact scientific processes of gaining insight in a multistep way, therefore hopefully fostering processual, social, and farther competences beneath raising content-related knowledge. The teacher or educator inherits a moderating and supporting role.

In the whole process, participants individually (and partly collaboratively) document their work to profit from this in different phases of the whole sequence as described hereby and synthetised in Table 3.

- In the first step, called 'Profiling', learners receive a strong incentive (prepared by the teacher or educator) in being confronted with the exposition of a phenomenon or an actual problem. It should have a peculiar interesting or surprising feature to raise questions and prompt further study. Learners re-enact and profile the phenomenon or appearance by creating a case description – solely descriptive. The phase ends with a collective roundup.
- In the second phase participants collectively speculate about the nature and effects of the phenomenon, while the educator moderates the discussion. A first set of investigation strategies is provided along required equipment. The learning group is encouraged to modify the strategies or come up with own ideas for exploration. The participants inquire the phenomenon and keep documenting, while the teacher or the educator arranges organisational aspects like follow-up meetings to share and discuss results, ideas, or failures or to plan next steps. Again, a collective roundup debriefs this phase.

- In the third and last phase, the aim is to explain and compare the results while casually strengthening related competences and possibly even self-concept, motivation, and interest. As a product, learners are required to facilitate some sort of paper or poster as a product, whereas the educator has to provide adequate guidance and support. The product has to follow, i.e., fulfil, certain rules regarding the structure and presentation – depending on context and circumstantial factors. The documentation from before is all designated to be used for the progressing product and discussion. In the end of PIC the learning products are presented.

In Annex 1 It is described an example of the PIC process applied to a learning experience at the Paedagogische Hochschule Weingarten University (PHW).

PIC PROCESS: PROFILE, INVESTIGATE AND CREATE		
PROFILE	Exposition of incentive phenomenon	Teachers and educators lead exposition; should be interesting/ surprising/ raising questions/ needing further study.
	Case description or profile of the phenomenon	Individual documentation (pictures, notes…) about just the effect/ observation without explanations
	Collective synopsis of individual products	Teachers and educators are as moderators
INVESTIGATE	Collective speculation and Investigation strategies	-Phenomenon (and relevant effects). -Default strategies and development of tools for exploring aspects; teachers and educators again are as moderators. -groups propose ideas and possibly modify provided strategies.
	Coordinated investigation and case file	Groups split work; teacher sets dates/ meetings to discuss & share results, ideas, failures, further activities…; individual documentation as case file
	Collective synopsis of the case files	Teacher as moderator
CREATE	Production of an outline: scientific paper or poster	Depending on group, context, guidance, timeframe; according to rules (structure of a paper); use documentation from steps P and I
	Presentation of the learning products	Teacher as organizer. Optional: public / larger audience

Table 3: Phases of the PIC process.

3.2.2. Inquiry-based learning process

Over the past twenty years, there has been a growing emphasis on the use of inquiry-based learning and teaching in science education. These approaches have been recognized as effective for both scientific literacy development and students' engagement and enthusiasm towards science (Abd-El-Khalick et al., 2004; Rocard et al., 2007; Crawford, 2014; Garcia-Carmona, 2020).

While inquiry-based learning is often associated with science education, its principles and approaches has been applied to other disciplines as well. Whether it is history, mathematics, language arts, or social sciences, inquiry-based learning encourages students to explore and develop their own understanding of the subject matter by exploring ideas, investigating real-world problems, modelling and arguing while taking ownership of one's own learning. It also inspires to make a shift from curricula subjects to an idea of learning for ideas, problems, issues in which both participants active investigation and communication are central.

Inquiry-based education in science typically involves several phases or stages that guide students through the process of inquiry and investigation which can be open, semi open or guided. In Table 4 it is described an example of typical phases taken from the experience developed in Inquiring minds project from the IBSE (inquiry-based science education) approach (NRC 2000). While the specific terminology and number of phases may vary in other model, these are not strictly linear, and students may revisit and revise their earlier steps as they deepen their understanding and encounter new questions or challenges.

The emphasis on active participation, the central focus on critical thinking, and the hands-on exploration throughout the entire learning process highlight some interesting features of the inquiry-based learning process such as the aim to make a sense of issues and problems and to engage with them as a whole, overcoming the disciplines division. These characteristics make inquiry-based learning process a valuable practical avenue to explore and interpret within the context of the SENSE. project aligning with the considerations that have emerged thus far.

INQUIRING MINDS PHASES PROCESS	
INITIATING AND ELICITING	Eliciting the knowledge, interests, ideas and motivation of participants. The teacher's or the facilitator's role is to help students draw on their own lives and experiences to discover things that interest them, make them excited, curious and want to ask questions.
DEFINING AND RESPONDING	Shaping, defining and focusing an idea or question, and making plans to research it further. The teacher's or the facilitator's role is ensuring student's can advance their inquiries meaningfully.
DOING AND MAKING	Students and participants research, design and construct in order to make a contribution in their chosen enquiry, and engaging in a variety of tasks depending on the nature of their enquiry. The teacher's or the facilitator's role, if necessary, is to encourage learners to manage their time, identify clear goals and monitor their progress.
COMMUNICATING, PRESENTING AND EVALUATING	Learners communicate, share and present their new knowledge and/or understanding with others.

Table 4: Phases of Inquiring minds project

3.2.3. Facilitation techniques

During any learning process in which many people are involved together and at the same time (such as at school or a meeting, in a workshop or in a participatory project), people with different knowledge, experiences, motivations, perspectives and personalities work together. When thinking on practices and activities within the SENSE. project, this aspect needs to be addressed while designing activities with tools and techniques to efficiently facilitate these collective moments so that participants can benefit from each other, and everyone can contribute to the construction of knowledge. These tools help to rapidly promote a vital and constructive environment, guaranteeing forms of participatory communication with strong circularity, the activation of individuals within a multifaceted context and the use of reflective feedbacking to improve results and findings.

The starting point in any collective learning process is that we are all working within the same experience. It is therefore worth making explicit and in a transparent way the context, the timeline, the resources that can be used and also to have some techniques and activities to be modulated and calibrated on one's own context, to ensure that everyone can participate and contribute to the construction of a collective knowledge grounded in the experience of all.

During the Bergen and Paris workshops, the consortium was able to try out some of these activities also thanks to the collaboration of the facilitators of Return on Meaning who moderated the first workshop (see for more details the Chapter 2.1 of

deliverable D3.1). These facilitation practices have been found meaningful also for the development and the implementation of the SENSE. methodology.

In Table 5 there is the list of the activities collected for the use in SENSE. with their goals and in Annex 2 there is an example description.

FACILITATION PRACTICES	
FAST NETWORKING	Understand expectations of participants and energize participants of a workshop/event very quickly (every participant gets to talk, to move, to think); introduce topic and get people started to think about it; also, clearly creates a work atmosphere (i.e., the participants are the owners and not the facilitator)
INTRODUCTION WITH RANDOM FACT	Introduce people; create some openness in the very beginning and potentially reveal common/interesting facts about participants (potentially as starting point for later conversations)
TIMELINE/INTRODUCTION MAP	Introduce people to each other; show similarities and common ground as well as potential differences; energize people
STAR REPORTER	Introduce people to each other, create a relaxed atmosphere, create a deeper relationship in groups of two
TWO TRUTHS AND A LIE	Encourage sharing of interesting facts; show similarities and common ground as well as potential differences
LASER FEEDBACK	Enhance awareness of own behaviours (through receiving feedback); advancing communications in a group about each other and the how of collaboration; practice giving/receiving feedback
TENT POLE	Create experience for participants on team dynamics; have participants experience the importance of having a leader in a team; create awareness for own behaviour, when no team leader has been nominated; provide basis for reflection on teamwork; energize people
FINDING COMMONALITIES	Increase "group feeling"/further getting to know each other; create awareness for the bounding effect of commonalities and thus relevance for the work context
GALLERY WALK	Discuss ideas in the team; foster ownership and commitment; encourage collaboration
FLASHLIGHT	Get opinions and feedback, needs, and expectations from everyone involved
POINT RATING	Get a quick prioritization of topics or a quick overview on preferences or opinions of the participants
KEEP/CHANGE	Ensure to get feedback on the process (the "how" of what we do)

Table 5: Facilitations techniques for SENSE.

3.2.4. Feedbacking techniques

Practices of reflexivity are intrinsic to engaging in learning for future-making, as learners need to be prepared for the challenges and emotional revelations that might

lie ahead of them. Consequently, reflective feedback is a primary pillar in the SENSE. methodology, and integrates the personal, community, identity, and development into STEAM education and into practices involving sensing the world. For the purposes of the SENSE. project, we define reflective feedback very generally, to include all forms of reflection and communication (and reflection-communication) that allow learners to evaluate and improve their own experiences. This includes both formal and informal feedback, self-reflection, peer feedback, feedback from teachers or facilitators, and the reflective feedback that occurs either in small moments or over longer periods of times that cannot be enunciated or pinned down so easily.

By taking a broad and inclusive approach to reflective feedback, we hope to capture the full range of experiences and perspectives that can contribute to meaningful learning and growth and offer various inset points for support and guidance in the learning process. Through this exploration, we aim to highlight the importance and benefits of reflective feedback in promoting STEAM and sensory education and provide examples of effective techniques and strategies that can be used in various contexts.

Two central themes of reflective feedback in the SENSE. project are co-constitution and embodiment.

- Co-constitution refers to the idea that learning experiences are not solely determined by the individual, but are also shaped by the group, community, and place in which they occur. This means that reflective feedback must take into account not only the individual's own experiences, but also the social and environmental factors that contribute to their learning.
- Embodiment, on the other hand, emphasizes the importance of the whole person in the learning process, including their senses, cognition, identity, and body. By expanding the sense of self to include not just the individual but also on other scales, for example of at the scale of molecules, body interactions, rooms, neighbourhoods, towns, regions, continents and worlds, we can create a more holistic and inclusive approach to reflective feedback that considers the full range of human experience.

Feedbacking techniques that are part of a SENSE.STEAM are ones that involve introspection of the self, communication within a group, and communication with a space or place. These three tenets become combined in the co-constitutive approach such that recognises what separates us and also what brings us together, and what blurs the boundaries between personal, community and political.

The importance, significance, and usefulness of these feedback techniques lie in their ability to promote self-reflection, collaboration, and creativity. By incorporating feedback techniques from the arts and beyond into STEAM and sensory education, educators can create a more inclusive and engaging learning environment that promotes self-expression and personal growth. These techniques can help learners to develop their skills and creativity, as well as build their confidence and self-awareness. Furthermore, these feedback techniques are transferable to other areas of

life and work, making them valuable tools for lifelong learning and personal development.

In implementation of SENSE.STEAM learning and activities, the project will integrate reflective feedback from participants, facilitators and others involved into all the activities. Because of the importance of future-making as an educational endavour, activities will be creative, open-ended and unique to context including place, community, time and the people and institutions involved. The efforts to seek feedback will also be creative and as open-ended as practically possible.

Each feedbacking activity includes links to elements of the SENSE. Manifesto, as well as to three pillars of reflective feedback in the SENSE. project, as mentioned above. Each feedbacking activity will also work within various constraints. The activity should be accessible within the constraints of the setting without many additional resources, and most should be possible to be carried out in around 15 minutes at the end of activities. An example of collection of feedbacking techniques can be found in Annex 3.

3.2.5. Hints for describing and developing new practices

Developing new methods for STEAM education requires a focus on both theoretical knowledge and practical implementation. One important aspect of this implementation is creating engaging STEAM practices.

A set of key features and hints based on over forty years of experience in developing enrichment courses has been put together by Julian Whybra (Whybra, 2022). We found them to be extremely useful for reflecting the transformative power of SENSE.STEAM activities:

- Any piece of extension material must provide an intellectual challenge through the quality rather than the quantity of work involved. It should be of an interdisciplinary nature, demand the highest standards, and should be on a subject which is either not on the syllabus or else is a genuine extension which does form part of the syllabus.
- The material should provide an opportunity for self-direction, for independence of thought and action, and for leadership and communication to develop.
- The material should provide an opportunity for originality and imagination to be demonstrated through problem-finding, creativity, sensitivity, logic and reasoning. If possible, the material should be open-ended.
- The material should provide an opportunity for individual attention such that the learner will find it necessary to discuss options with its peers, their curriculum extension teacher, and other adults.

- The material should be based, according to good educational practice, on primary sources or first-hand experiences and contain opportunities for extensive reading, should the learner desire.
- The material should be obscure enough to be interesting and interesting enough to be compulsive.
- Any initial attempt at writing suitable materials should be on a topic about which one can enthuse infectiously.
- After the material has been used, it should be evaluated, revised, and re-trialled, until a satisfactory final format has been achieved. The writing of teachers' notes is an optional, time-consuming but worthwhile activity, especially if others are to use the material. They are also useful for evaluation purposes to see whether aims and objections have been met.

These hints provide a valuable guiding force for educators and curriculum developers seeking to create innovative SENSE.STEAM practices. While these insights are not prescriptive, they can provide valuable guidance for ensuring that new practices are interdisciplinary, intellectually challenging, and foster self-direction, originality, and individual attention. They also emphasize the importance of evaluation and revision to ensure the quality of STEAM practices. By highlighting the relevance of interdisciplinary approaches, originality, self-direction, individual attention, evaluation, and revision, these hints can help to ensure the development of effective and engaging while at the same time empowering practices. The nature of the SENSE. approach expects creativity and resourcefulness unique to the context, including the time, place, community, and other factors, where the practices and activities are being carried. As such, these hints provide jumping off points and places to begin in the 'future-making' process of a SENSE.STEAM educational practice. The design allows for the results to sometimes be not what is expected.

4. The co-creation of the future learning companion

Stier and Smit (Stier and Smit, 2021) highlight the need for trans-institutional co-creation in scientific research, as it is recently "often argued that academia, government, industry and societal partners [...] have much to gain from intersectoral collaborations." (p. 2). They proceed to provide this statement's general reason which we can easily apply on our context of contributing to the development of an international roadmap to STEAM Education across Europe: "From a policy-making perspective such collaboration is viewed increasingly as a necessity when puzzled with the grand challenges – may it be economic recessions, public health concerns [...], global warming or trying to accommodate austerity or counteract extremism." This kept in mind, to create something meaningful and sustainable with respect to all beneficiaries and stakeholders as well as vulnerable groups or guiding topics of

future-making education and progressive, scientific literate, society, it seems lucid and reasonable to approach this creation collaboratively.
The comprehensiveness within the SENSE. project, provided by the various consortium partners and extended by the associated partners as well as further collaborating institutions or professionals, has been mentioned and hooked up on in plenty of our former plannings and reports. In conclusion, it seems only logical to even intensify this co-creation when approaching and discussing practical applications and activities that (inter alia) constitute our methodology.

In terms of augmenting partners' professional, individual, and contextual (implicit) knowledge and experience, the key was to develop formats and strategies that would allow insights to be gained through the diversity of contributions from different partners and stakeholders. Beneath the organisational aspects of sharing contacts, arranging in-person workshops and scheduling meetings it was also mandatory to form a positive, productive, constructive and appreciative culture of interaction among collaborators. The importance of interacting and networking is also outlined in chapter 2.3 of this report.

The work summarised in this section is intended to develop a clear description of the comprehensive and systematic approach to identifying practices that will be characteristic of SENSE.STEAM. These practices include, for example, learning activities, design strategies and reflection principles (see section 3). All practices are designed for STEAM stakeholders and beneficiaries to create and implement STEAM education across the learning continuum. On this basis, we have compiled a collection of SENSE. practices, mostly activities, which will be evaluated and modified during the implementation phase in the second year of the project.

However, before we were able to present a list of SENSE. practices, it turned out that an extensive learning and reflection process was needed within the whole consortium. It was very enriching that this development work built on the collective experience gained during the STEAM DNA and Citizen Science and Art Practices workshops.

4.1. The co-creation approach: from individual praxis to common grounds

For the STEAM DNA workshop (see chapter 2.4.1), participants were encouraged to bring a practice from their context that they would like to share and discuss with the workshop participants. For the documentation of these practices (to have a transcription and to get feedback) a short template called ID Card was designed and provided to the participants (an example is given in Annex 4). The guidance was minimal, the facilitators just had to bring a practice that they felt was in line with STEAM. Participants first tried out the different practices, mostly learning activities, and then discussed them in a subsequent cluster, which can be

considered as the first input for the SENSE. learning companion. The practices were analysed for commonalities with the aim of distilling characteristics of a 'STEAM practice', leading to a more concise understanding of key characteristics in *doing* STEAM and defining the SENSE. approach as an 'educational practice'. As a result, during the workshop, a small group of people prototyped a first list of characteristics of STEAM activities and summarised them as four preliminary guiding principles (An extensive description is depicted in D3.1):

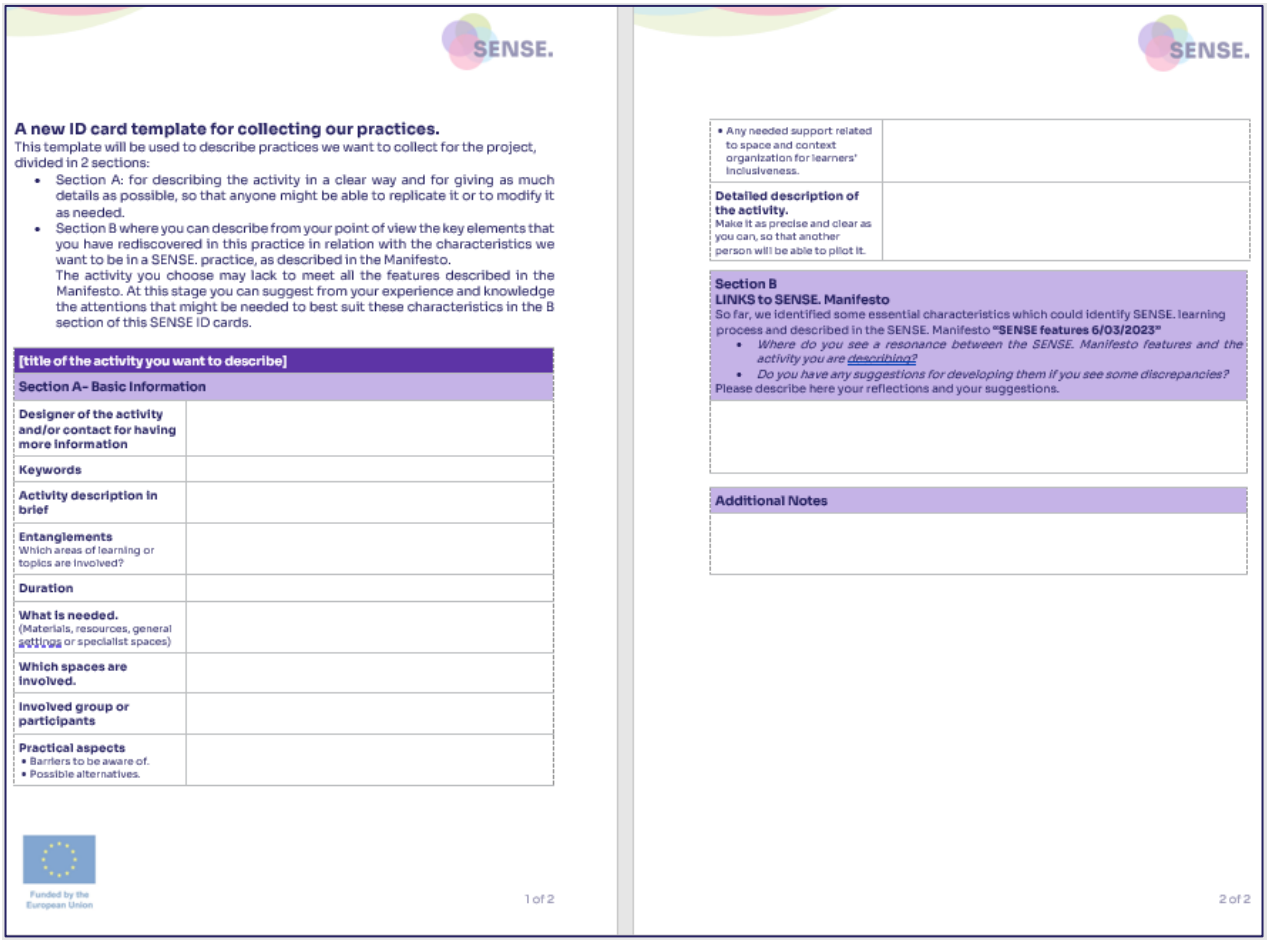
- Respect and align STEM with *A*rts in learning goals, learning activity, and the assessment of the learning outcome.
- Promote creativity and active participation.
- Include sensory experiences and attentiveness.
- Support individual and collective learning – linked to real life.
  An extensive description is depicted in D3.1.

From this practical experience, an important conclusion will accompany the whole process of activity description and development of SENSE.STEAM as an educational practice, feeding into the description and therefore ongoing co-creation of the Learning Companion as regards its prototyping: it is neither effective nor useful to try to characterise and frame individual STEAM activity practices as universally as possible, as this would mean a loss of detail, tacit knowledge and applicability. The practices themselves as well as the aforementioned guiding principles behind them should rather be understood as a framework of practice for STEAM to enable beneficiaries and stakeholders as well as STEAM labs to implement and design STEAM activities and practices fitting their needs, target audience and contexts.

To further imagine the SENSE. learning companion, it seemed crucial to consider and evaluate further pedagogies, insights, and practices. As described earlier in this report in chapters 2 and 3, we therefore jointly researched, discussed, planned a second workshop on citizen science and art interventions, and involved different sources of input, ranging from personal feedback and workshop or discussion outcomes, to inspirations for learning sequences from different projects or seminal books and articles, to different types of publications (articles, books, lectures, in academic, philosophical, practice-oriented or epistemological contexts). We also collected and documented new STEAM activities, also according to the project's KPIs 1.1 & 1.2, which set out to collect, review and document practices from educational contexts as well as from citizen science and art interventions. The common aim was to describe new inspiring practices in a way that was comprehensive and precise enough to be understood as a basis for further reflection and development, but at the same time open and practical.

During this phase, communication structures were strengthened, leading to various regular semiformal exchanges and co-creation and feedback within the work package. In addition, all work in other parts of the project was constantly examined for crucial interrelations or mutual inputs and meanings. Based on the variety of inputs and the constructiveness of the exchanges and progresses, a common ground

continued to emerge (and continues to do so), while as a result, first extensive descriptions of what STEAM sequences are or can be were merged and shared, sorted, refined and modified by different partners - leading to a first prototype of a new description template described in Figure 9 and to the creation of an updated and enriched list of relevant features that should shine and inspire the description and even development of the SENSE. learning companion. This list of features, called the SENSE. Manifesto, taking its name from the artistic background, was also included in the Practices Template to stimulate reflection and facilitate imagining the kind of material and learning process to be implemented in STEAM labs.



A new ID card template for collecting our practices.

This template will be used to describe practices we want to collect for the project, divided in 2 sections:

- Section A: for describing the activity in a clear way and for giving as much details as possible, so that anyone might be able to replicate it or to modify it as needed.
- Section B where you can describe from your point of view the key elements that you have rediscovered in this practice in relation with the characteristics we want to be in a SENSE. practice, as described in the Manifesto.
  The activity you choose may lack to meet all the features described in the Manifesto. At this stage you can suggest from your experience and knowledge the attentions that might be needed to best suit these characteristics in the B section of this SENSE ID cards.

[title of the activity you want to describe]	
Section A- Basic Information	
Designer of the activity and/or contact for having more information	
Keywords	
Activity description in brief	
Entanglements Which areas of learning or topics are involved?	
Duration	
What is needed. (Materials, resources, general settings or specialist spaces)	
Which spaces are involved.	
Involved group or participants	
Practical aspects • Barriers to be aware of. • Possible alternatives.	

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• Any needed support related to space and context organization for learners' inclusiveness.	
Detailed description of the activity. Make it as precise and clear as you can, so that another person will be able to pilot it.	

Section B
LINKS to SENSE. Manifesto

So far, we identified some essential characteristics which could identify SENSE. learning process and described in the SENSE. Manifesto **"SENSE features 6/03/2023"**

- *Where do you see a resonance between the SENSE. Manifesto features and the activity you are describing?*
- *Do you have any suggestions for developing them if you see some discrepancies?*

Please describe here your reflections and your suggestions.

Additional Notes

2 of 2

Figure 9: ID card template for collecting and understanding practices in the frame of SENSE.

4.2. The SENSE. Manifesto

The SENSE. Manifesto (Figure 10) is a living document and materialised through collaborative dialogue and iterative contributions from the consortium, capturing evolving insights and perspectives to shape a dynamic and inclusive framework for SENSE. educational settings. The Manifesto serves two purposes: i) It is a living document that succinctly articulates the shared principles, values and goals of the partners and serves as a guiding framework that unifies the efforts of its members. ii) The articulation of a common, clear vision helps to communicate the project's distinctive perspective and transformative vision to STEAM stakeholders and beneficiaries.

During the co-creation of SENSE.STEAM in the implementation phase (WP4) and to envision the transformative character of the final roadmap (WP7), the manifesto also serves to frame the ideas developed to date and to clarify the guiding principles and values that will inform the identification, collection, understanding and design of practices. These practices form the applied part of the SENSE. methodology (D3.5) and are crucial for the actual relevance and transformative potential of the SENSE.STEAM practices relevant to the SENSE. context project. In addition, working on this manifesto has helped to establish a shared vision among the consortium and other stakeholders and beneficiaries. It fosters a sense of common purpose and can promote collaboration, communication, and cohesion within our educational communities to plan the next actions of the project. The format of the manifesto is also intended to encourage innovation and experimentation. The short explanations and questions that accompany each statement encourage the exploration of new ideas and approaches for STEAM labs within the boundaries set by the guiding principles, fostering a culture of openness, creativity, and experimentation.

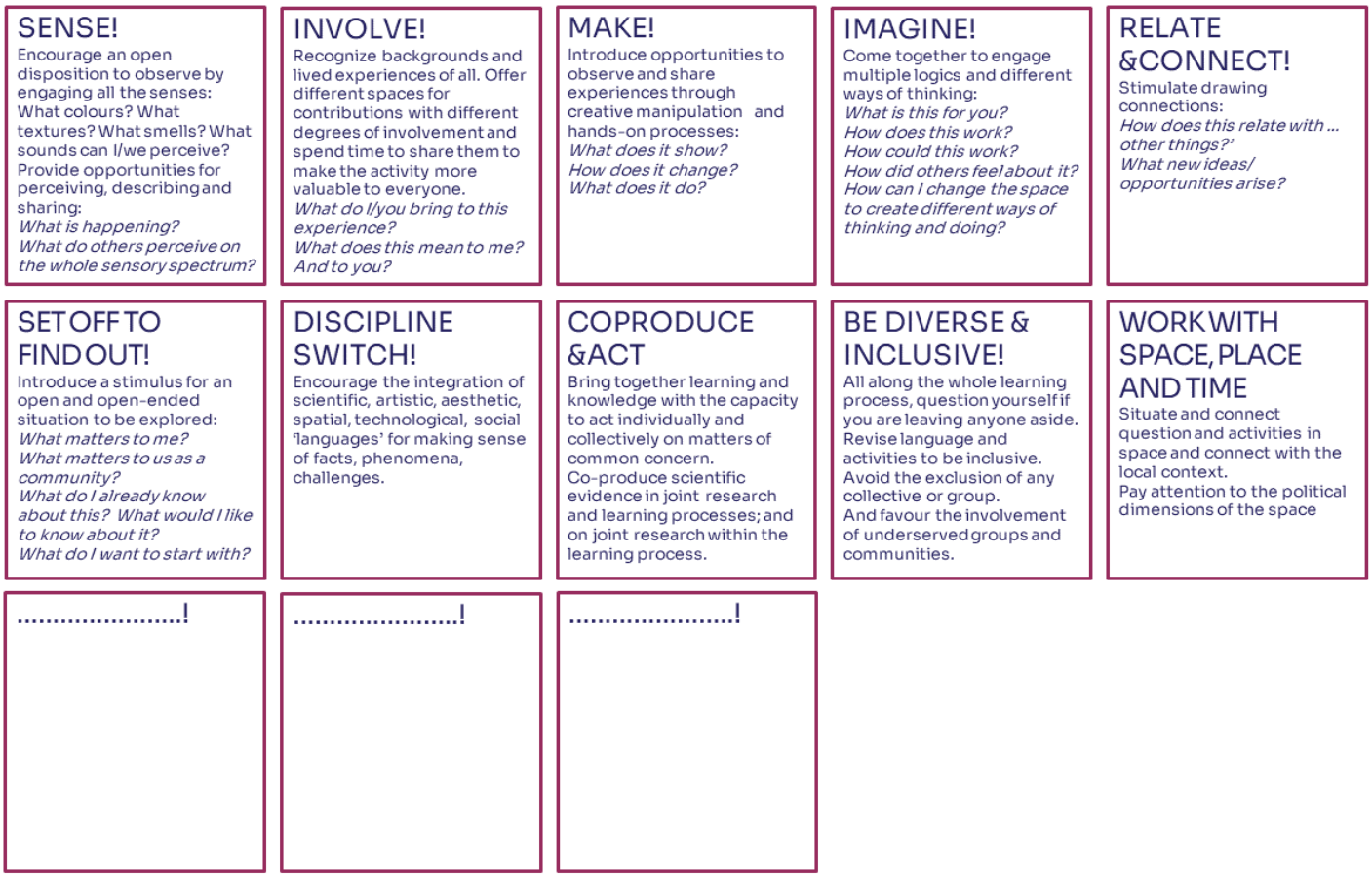

Figure 10: SENSE. Manifesto updated to May 20, 2023. Blank cells can be used to incorporate further characteristics should the need arise during the next steps of the project.

To enhance the lived experience of its use and applicability, the SENSE. Manifesto was sent out to the partners along the related practices description template described in Fig. 1 with the request to use it for the envisioning and description of a STEAM, art intervention or citizen science practice of their choice and context, and with a plea for feedback on its applicability, benefits, and constraints to be shared during the workshop on citizen science and art interventions in month 7 of the project. This discussion enlarged the understanding of our variety of practical approaches and inspiring contexts – therefore contributed to our co-creation processes of how practices or learning sequences in SENSE. can be envisioned. The use of the Manifesto showed that there is no pre-packaged recipe for designing or seeking a practice within the context of SENSE. On the contrary, the Manifesto encourages each of us – educator, teacher, facilitator, explainer - to identify the characteristics of our educational context and consider the needs and ideas of the learners and participants who will experience that specific situation while designing the possible practice, activity, and intervention. With this intention, the Manifesto establishes a framework of considerations to outline the starting point of each learning situation and to situate the type of educational interventions to transform the learning from a conventional STEM education process – characterised by a confirmative, content based, illustrative

and pragmatic situation- to a one oriented to an experimental, multi-sensory, future making and translative learning situation.
The Manifesto enables explicit examination and questioning of boundary conditions and the actions required to move in the spectrum between the two poles towards learning processes characterized by future-making interactions, allowing participants to notice, perceive, and do things in different ways, fostering the imaginative side of education and bringing it to life.

4.3. The collection of SENSE.STEAM practices

The basis for the compilation of the project's set of practices was established through an examination of the diverse learning enterprises related to STEAM already underway within the consortium's constituent members. This deliberate effort was significant as it sought to comprehensively capture and document the diverse range of experiences and initiatives already undertaken or known to the partners through the lens of SENSE. This analytical process, in conjunction with the formulation of the Manifesto, also has the potential to effectively identify indicators that can guide the future conceptualisation and development of the SENSE. roadmap, its materials, activities and practices for the forthcoming phases outlined in Work Packages 4, 5 and 6. In total, the consortium has gathered a collection of 55 different activities, spanning the fields of STEAM (35 practices) as well as citizen science and artistic intervention (20 practices).Partners have selected and described interesting activities and practices from their own experience and analysed them in terms of their potential and limitations in relation to the SENSE. Manifesto and their attitudes towards learning for the future. It's important to stress that this collection of activities and practices does not yet embody all the SENSE. characteristics identified so far. On the contrary, they have facilitated the individualisation and the sharing among the consortium of insights, in particular in relation to the link between art and science in education, to the involvement of the community, the necessity to integrate feedback activities or approaches to sensual involvement. The aim at this stage was neither to have a prototype for a SENSE. activity or SENSE. reflection tool ready nor to have a complete understanding of what characterises the SENSE.STEAM practices as the applied part of the methodology by the end of the first year. On the contrary to be able to create a common language among the partners and to establish a shared vision of the direction to take, based both on practice and on the collective aspirations and goals expressed in the Manifesto. By bringing together different voices and perspectives, this co-create process can foster a sense of shared journey towards an innovative and inclusive way of interpreting science and arts education.
All practices are archived in the SENSE. project cloud web space (see Figure 12) and are available to partners for future explorations in the design of SENSE. materials. Their list and brief description is described in Annex 5.

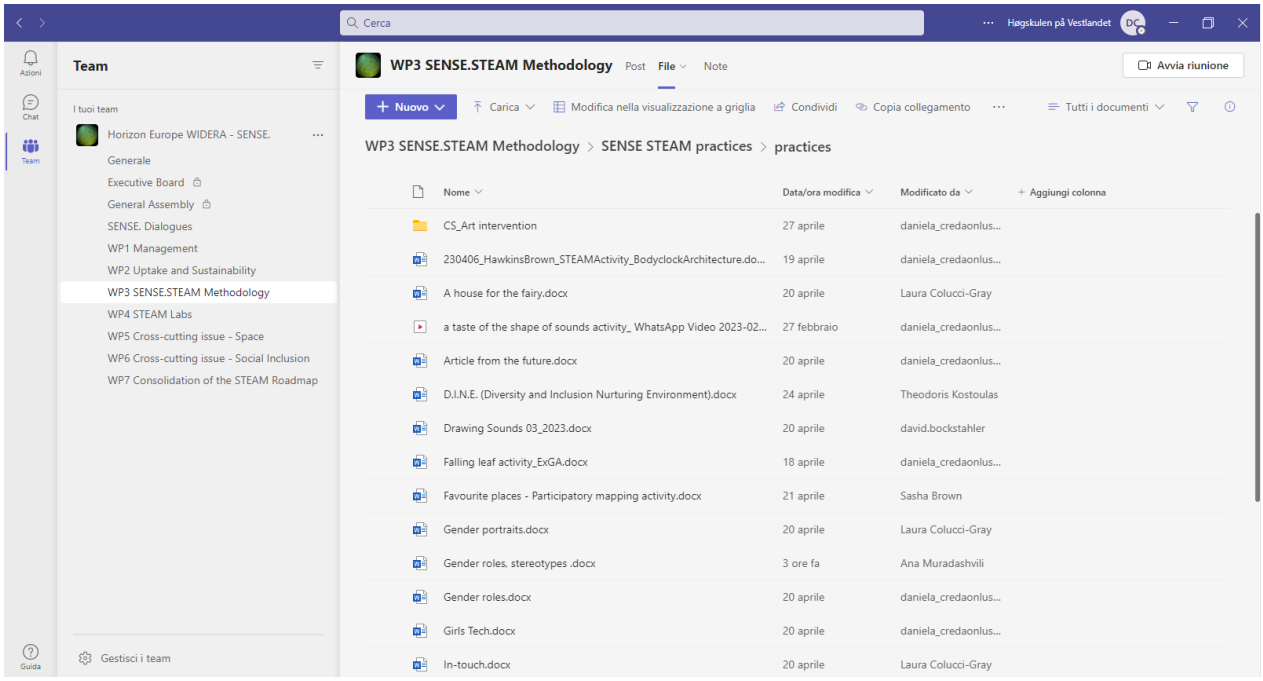

Figure 11: SENSE. WP3 folder for the archiving of the 55 partners' practices for SENSE.

4.4. Insights from the Collection of Practices

A critical analysis of the practices collected by the consortium has been undertaken. The aim is to reflect, establish common ground and identify sensitive areas that require innovation to create effective approaches to STEAM education in SENSE.
The analytical approach is twofold. One, for each practice there are reflections provided by the partners on the values and principles described in the SENSE. Manifesto. Secondly, these reflections have been interwoven with insights from the work collected and presented in chapters 2 and 3.
These reflections are neither exhaustive nor definitive. They serve as an initial framework for the SENSE. methodology and for the design of the STEAM laboratories to be developed in WP4. In addition, these considerations can be further explored by the two working groups, WP5 and WP6, which will address the issues of space and inclusion that have emerged as critical in the explorations reported.

Inductive learning pathways One of the common threads that can be identified among the wefts of the analysed practices is the inductive pathway of learning from direct praxis which characterises them, with interesting implications on choices for learning settings and spaces, for frequency and the use of time and for the role of observation and deep attention in education. Its focus is on examining the particular and unique instances or phenomena first and then deriving more general categories or concepts from them. It emphasizes the importance of individual experiences, perspectives, and context in shaping our understanding of reality. This approach recognizes that the understanding of the world is not solely determined by

predetermined categories or universal principles but is influenced by subjective experiences and interactions with the world.

Practicing real-world learning. The usual paradigm of STEM teaching, often found even in active learning contexts that use inquiry-based learning approaches as described in chapter 3.2.2 of this report, involves the use of models, experiments, or other educational iconic, analogic, symbolic mediators such as the use of videos, readings, explanations, games, role playing, pictures, drawings, diagrams, interactive digital tools. The aim here is to help learners in visualizing or reproducing, while simplifying, explaining or translating facts, laws, and phenomena to approach curricular content and create 'knowledge'. Often, after this mediated phase, teachers and educators propose to learners a real and authentic challenge or situation in which they can consolidate their learning, knowledge, and skills by applying what they have learned before or at least by transferring what they learned to another context or domain. Instead, some practices presented here turn the idea of the learning context upside down. In place of using models and educational mediators that reproduce the subject of the lesson etc, from the beginning they present as learning contexts the real and authentic world of facts, things, phenomena, and interactions that take place in communities or in urban and natural spaces.
Students and participants approach contents and learn directly from being in and experiencing such a rich and whole real-world situation and through the phenomena that naturally occur there or in which they actively participate. Only after then, they break down the complexity of what they have experienced and begin to recognize its constituent elements, patterns, differences, relations, implications, using and transforming what they have learned in that situated situation. In this second phase feedbacks, reflections, discussions, elaboration with also those iconic, analogic and symbolic mediators and tools described above, are largely used.
This is a shift that requires new approaches to teaching: the formal education system needs to integrate open schooling experiences, non-formal, and informal learning possibilities and to open up to the community and to the outside world. From direct and tangible experiences, teachers and educators, together with students, citizens, and participants, co-create a *situated knowledge* which is meaningful to them because it creates meaning of the world around them. Even the idea of the school curriculum itself needs also to adjust from a set of contents to be known, to a set of knowledge, values and skills that builds up from situations, experiences, emotions, concrete problems, exchanges which are, possibly, relevant to learners.

The importance of out-of-classroom spaces. The types of learning just described and envisioned in some of the collected practices cannot be organized only within the walls of the classroom. The space and the places need to communicate, expand and embrace the outside world in its social, environmental, political dimension, wherever necessary. Learning places welcome and open to the outside which enters synergistically into education to significantly increase the quality of the experiences.

At the end, it is an ecological way of looking at educational spaces as a system, seen as a multidimensional and interactive whole that learns and changes. Neighbourhoods, urban and natural places along with all the spaces where life occurs (museum, factories, city hall, community spaces, ...), are all critical and need all to be considered.

Certainly in some of the practices, cities are the place to live and understand the major issues of contemporary society – just to name a few: social norms and cultural values, quality of life, sustainability, growing poverty, energy production and consumption - but also the place where to understand how such a complex system works and dynamically acts as an ecosystem - imagine for example the interconnected flows and networks between people and other living species, biomass, abiotic factors, water, heat, light, waste, electricity, energy, sound, food, services, etc. But urban places are also the hub of our actions where exchange of practices occur and where people act and transform, imagine the future and create solutions. At a closer look, even the smallest patches of our streets, houses and buildings, the variety of political, social and economic activities that take place there, the exchanges in thoughts, emotion and experience between living beings, the urban nature which flourish in re-naturalised spaces carved out from the built ones, all show multiple possibilities to explore ourselves, challenges, ideas and interrelationships. Students can interact with the physical part of cities, with cultural diversity, with complex social interactions and the interrelationship between science and social and sustainability issues and be immersed in a physical environment where phenomena and facts are there to be explored and experienced.

In some experiences natural spaces seems also important not just for the myriad of so-called "natural science contents in the curriculum" availability for direct exploration in natural spaces, but significantly because the natural world becomes the predominant setting for learning through sensory experiences, as if it serves as facilitating contexts for opening doors to sensual observation and attentiveness. It has been three and a half centuries since the renowned apple of Isaac Newton detached from the tree and fell on the head of one of the pioneers of modern science, inspiring him to formulate the law of gravity (or at least that's how Newton himself described it in his memoirs a year before his death in 1727). During the discussion that followed the experimentation of the "falling leaves" practice at an online partners meeting, we found ourselves reflecting on whether the opportunity to lie down on the grass, idle away, and enjoy the canopy of a tree, and subsequently experience the discomfort after the apple fell on one's head, played a fundamental role in embedding and understanding the concept of gravity.

Participation and learner centeredness. All the practices mentioned demonstrate a focus on the active role of students in directing their own learning, moving away from traditional instructional and teacher-centred approaches and can offer opportunities

to knowledge co-production. This is particularly evident in the citizen science and art intervention practices, where participants are encouraged to develop agency and explore various options for addressing their own concerns.

Slowness and wandering. Time seems to play a critical role. Even though many practices reported its duration, in the description of the practices emerged the need to carefully decide the timing in relation to the situated interventions and in relation to the participant's interest. Timing influences the flow and progression of the learning process, allowing for appropriate reflection, consolidation, and integration with a general hint to search for slowness rather than proposing a learning journey at full speed and a suggestion to de-link the learning journey to just utilitarian logics of functionality or of curricula needs and give the possibilities to learners to follow their instinct, intuition, curiosity.

Entanglements. Cross-disciplinary or transdisciplinary character – although not yet aimed on integrating arts and science - is not always recognisable or a strong element in many of the practices even if they are already showing that the exploration of phenomena/nature/issues go beyond subjects or classical disciplines. This aspect may need further reflections also because it can become a barrier when it comes the moment to links the SENSE. methodology to the current way to interpret the curricula objectives especially in formal education settings as it was indicated in the stakeholders needs assessment (for a deeper reading on this, see the deliverable D3.3).

Art & science. In the collected practices within the realm of STEAM, there appears to be a prevailing notion of Art infusion rather than Art integration, with examples where art seems to serve more as a facilitator for fostering creativity and motivation. It seems, therefore, that the goal of SENSE! to create situations where scientific and artistic inquiry both play a primary role towards true transdisciplinarity is one of the most crucial points for the consortium to concentrate on and experiment with.

Open-started & Open-ended. While many practices aim to provide participants or learners with ownership and empowerment by adopting an open-ended approach, several practices demonstrate instead a clear initial intention from the teacher or facilitator to guide the beginning of the activity or practice. On the other hand, citizen science and art interventions practices seem both to offer more opportunities for participants to have also open-started entry points, setting the condition for allowing them to decide the context and the objects of their enquiry or work contribute and engage in a more flexible manner.

Action. There are many opportunities for learners to make decisions and take initiatives in the collected practices to a imagine an actionable knowledge in daily contexts. Perhaps the citizen science practices, and some intervention practices display this clearly because frequently their aim is to encourage participants to make contributions towards improving the quality of their community or addressing

societal issues. However, at the same time, most of the collected practices can also provide valuable implications or clues that allow us to envision the development of this aspect.

Sensual inquiring. There was a clear intention to collect practices that can offer various entry points for exploring and inquiring into the proposed situation with multiple perspectives, senses, and logics for engagement. It seems that, despite this type of inquiry not being frequently present in learning settings, particularly for secondary school students and above, there are instead many possibilities to develop and move towards this direction.

5. Conclusions

The first year of work in WP3 of the SENSE. project and the knowledge and expertise gathered and described in this report explores the potentialities of STEAM education while defining the core aspects to be included in the SENSE. methodology.
In this journey, we have explored new territories in the realm of STEAM education, pooling together the wealth of knowledges that each partner brings and has developed in various fields: some in citizen science and art interventions, others in formal education, non-formal education, workplaces, museums, collaborating with diverse stakeholders in different spatial and geographical contexts.
We all shared the same goals: to challenge the idea of STEAM education as a mere combination of disciplines, where the arts are included alongside scientific disciplines, implying a certain subordination of art in aiding and facilitating the often challenging and not always accessible encounter with scientific disciplines.

Experiences in different fields such as art performances, natural sciences, citizenship and sustainability education, physics, tinkering, music, theatre, participatory design, and geography to name a few, have enriched the central idea that our focus should be less on what aspects SENSE. should concentrate on and more on how learning takes place significantly for the persons involved in a specific space and time. Therefore, seeking to synthesize and present the knowledge and insights, which ignite the forming of SENSE. methodology, we propose the following reflections and take away points that emerge from this journey. Keeping the metaphor of the journey in mind, these directions may open windows and vistas for further new incursions to take the challenge towards the transformative opportunities that come with STEAM education.

5.1. Lessons-learnt for the development of the SENSE. Methodology

- The SENSE. approach is grounded in the aim to promote artistic and scientific inquiry practices on equal terms (Burnard, Colucci-Gray and Sinha, 2021). In fact,

the insights gained from the art and science integration approach described in this report are crucial for the development of the SENSE. methodology because it acknowledges the transformative potentialities of imagination and individual attentiveness. This approach recognizes the essential roles of both arts and sciences and their synergic contribution to the creation of collective knowledges, forming an inseparable connection.

- STEM+A in SENSE. means an intention for tuning in for a type of learning that questions social, personal, and physical matters through a dynamic, aesthetic, and phenomenological understanding of the world.
- SENSE. develops an inductive and phenomenon-based approach to learning while moving away from a reverse ontology approach focusing instead on transdisciplinary applicability and promoting phenomena worth investigating. The integration of STEM and aesthetics is an essential component of phenomenological approaches, without the need for artificial additions.
- SENSE. embraces the need of redefinition of the conventional notion of knowledge by shifting the focus from disciplinary concepts to subjective and collective embodied experiences. This approach challenges expectations, encourages experimentation, promotes diverse perspectives and encourages individuals to take ownership of their learning and of its transformative potential.
- The methodology addresses overlooked methodological aspects of traditional education and training. Instead of deductive, static and linear ways of learning we emphasize the co-creation and ambiguity of creating knowledge, as well as the social and situational nature of knowledges creation.
- Learning in formal and non-formal settings needs to consider the experimental potential of aesthetic knowing and of sensual knowing. Here we want to take into account the importance of the whole person in the learning process, including their senses, cognition, identity, and body. By broadening the understanding of self to encompass not only the individual but also various levels of complexity, resulting in a more holistic and including perspective.
- We aim to foster a shift in perspective in teaching, where the student surpasses the passive role of being a mere recipient of contents, to which they are often confined, and instead recognizes the centrality of each own learning journey, acknowledging their potential to shape and transform the social and environmental conditions of our lives. In the perspective of SENSE. methodology, the participant gains decision-making power rather than remaining a simple recipient of key subjects to better known to deal with the challenges of our times.
- To achieve the above, the experiences that the consortium developed at the Paris workshop have led us to consider that participatory science and art intervention practices are crucial in envisioning a different educational approach aimed to democratises education and learning.

- Promoting inclusivity at various levels and indorsing inclusion awareness need the use of various strategies, which involve: a) constant reflection to avoid excluding any groups or individuals from planned activities, b) balancing power and sharing responsibility among all participants, c) building trust and fostering a safe, informal atmosphere for free expression, creating a non-judgmental environment where all participants feel respected, d) empowering participants to address their concerns and explore options for action; e) recognising and valuing the diversity of perspectives and needs.
- Space and social relations that take place in the space where learning occurs are not neutral, so both need to have a strong recognition in the project methodology. There are not fixed rules, but instead four categories and related questions to bear to analysis the physical learning environment were found so far. They are the function and the recognition of the needs of the people using the space; the appearance and the kind of emotions that environment evoke; the environmental conditions, such as light, temperature, smell, air, noise and, finally what is the actual or the desired spatial configuration around the users.

5.2. Strategies and guidelines from the SENSE. Manifesto

The project's Manifesto is a lived document and serves as an intermediate instrument that captures the approaches, directions, knowledge, insights in their essence and hence facilitates the evolution and cocreation process for the SENSE. methodology. It presents them in a simple and straightforward manner, reflecting the project's values that the consortium identifies with and aims to promote, particularly in the methodology, to ensure their recognition and inspiration for the progression of the Roadmap and in the work of the other work packages.
In the process of drafting the Manifesto entries, another tangible result is also recognized. The members of the consortium have started building the project's alphabet and a common language. Certainly, this sensitivity that recognizes constructively similarities and differences will need to be carried forward in the other work packages to ensure consistent developments and evaluations.

From the work carried out and the resulting Manifesto document, the following specific indications have emerged to guide the consortium in the planned next steps of the project:

- Sense! SENSE. recognises the primary role of the body in knowledge, investigation, and exploration. The aim is to restore dignity to the body, which sensually and sensorially knows, produces, and communicates knowledge as a living being, as Claude Lévi-Strauss noticed in Structural Anthropology (Lévi-Strauss, 1973): '*We began by cutting man off from nature, and by constituting him a sovereign reign; it was believed that this erased its most indisputable*

character, namely that it is first a living being. And by remaining blind to this common property, we have given free rein to all abuse.'

- Involve! We acknowledge in the SENSE. project the active participation in fostering understanding, collaboration, and growth. By actively engaging individuals, and creating context where voices are listened, individuals feel empowered to contribute with their unique perspectives and collectively act for meaningful outcomes.
- Make! We recognize the transformative power of making, tinkering, crafting. In the act of making, mind and body are intertwined as one, creating a seamless unity of thought and action. Through the act of making, our thoughts manifest into tangible form as we engage our physical senses and tap into our cognitive faculties, as we work with others, in a specific environment and with specific materials.
- Imagine! Through the act of imagining, we can ignite a spark that fuels creativity and propels us towards new possibilities. Through imagination, we switch from a type of learning that involves reproducing and modelling known facts to one that embraces the own unknowns.
- Relate and connect! The importance of relating and connecting in the learning process lies in embracing a systemic mindset. By enhancing the interconnections and interdependencies between ideas, facts, and sensory experiences, a holistic understanding emerges that transcends isolated knowledge.
- Set off to find out! With SENSE., we invite to get moving and to explore new horizons, genuinely seeking knowledge and experiences beyond what individuals or group of individuals already know.
- Discipline switch! The SENSE. methodology should encourage a shift in the lens through which content is typically perceived, transcending disciplinary boundaries. By embracing interdisciplinary and transdisciplinary approaches, we foster a holistic understanding, enabling to see systemically and create nonlinear connections that generate understanding and knowledges that are meaningful.
- Co-produce and Act! In the methodology, the focus is to empower individuals to co-create knowledge with others, allowing both individuals and communities themselves to feel empowered to make decisions and drive significant change.
- Be diverse and Inclusive! The key point is that no one should be left behind. The methodology should encourage also a phase of courageous context analysis and needs listening.
- Space and time! The choices regarding timing and spaces that characterize the context of a learning practice have a significant impact on the learning itself. The invitation is not to passively accept the spatial and temporal organization, but rather to investigate and explore the potential of these two factors in order to create effective and meaningful situations for the individuals involved. It is important to actively engage with the possibilities offered by timing and spaces, shaping them to enhance the learning experience and create an environment that is conducive to meaningful engagement.

5.3. Future steps for creating local relevance, accessibility and impact

The critical analysis of the STEAM practices, viewed through the magnifying lenses of the Manifesto and through the intertwined knowledges, practices, and reflections of the partners, offers significant insights and reflections for drawing the project methodology itself but also for the implementation of the STEAM laboratories in WP4 and the shaping the future development of research and praxis in STEAM education.
In this final chapter, we provide a concise list of the key insights and findings from this work, considering their implications for future developments.

- Inductive learning pathways that prioritize direct experiences and individual context have implications for learning settings, spaces, time utilization, and the role of observation and deep attention in education. They emphasize the importance of subjective experiences and interactions in shaping understanding.
- Real-world learning practices challenge the traditional STEM teaching paradigm by immersing students in authentic situations from the beginning of the learning pathway. Participants learn directly from authentic situations, phenomena, dealing with the complexity of the circumstances and recognizing constituent elements, patterns, and relations.
- Learning experiences should extend beyond the classroom, embracing the outside in its social, environmental, and political dimensions. Open schooling experiences, non-formal and informal learning opportunities, and community engagement are essential for creating situated knowledge that is meaningful to learners.
- Educational spaces should be viewed as multidimensional and interactive systems, integrating neighbourhoods, urban and natural places, and various spaces where life occurs. Cities provide opportunities to understand contemporary issues, complex systems, and interrelationships.
- Sensory experiences in natural spaces facilitate deep observation and attentiveness, opening doors to understanding phenomena and concepts. Sensual inquiring enhances engagement and learning possibilities.
- Timing plays a critical role, allowing for appropriate reflection, consolidation, and integration in the learning process. Slowness and de-linking from utilitarian logics promote deeper learning experiences.
- Attention to cross-disciplinary or transdisciplinary approaches clearly emerged from the analysis but further reflection is needed to align them with curriculum objectives.
- Art infusion is prevalent in the collected practices, serving as a facilitator for creativity and motivation. Further goal in SENSE. is to experiment with true transdisciplinarity and move towards art integration.

- Many practices adopt an open-ended approach, empowering participants to make decisions and take initiatives. Citizen science practices and art interventions offer also flexible entry points and opportunities for engagement empowering participants to play an active role in their own learning and contribute to addressing their own concerns.
- Ownership and empowerment are key aspects of the learning process to bear in mind. The focus is especially into actionable knowledge in daily contexts, addressing societal issues.

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7. Annex 1

7.1. Example of PIC process

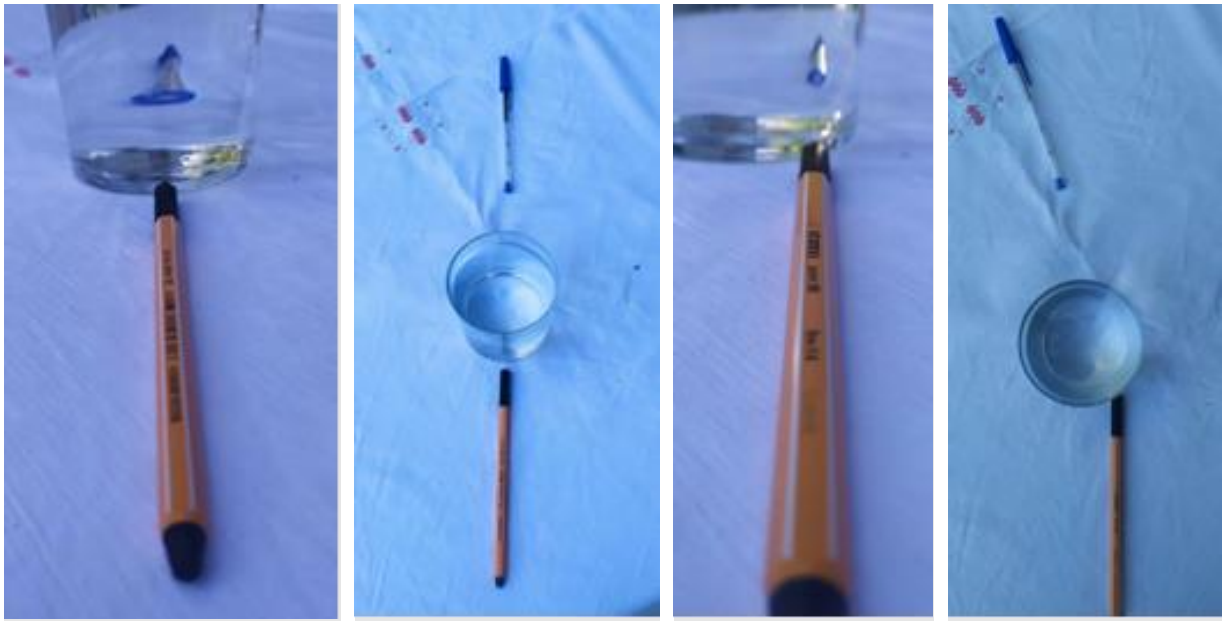
An example phenomenon presented to students (as a strong incentive): A glass of water is distorting the perspective on parallel lines from the placemat (left and middle). Even worse, a considerable portion of the finger becomes invisible behind the glass (right).



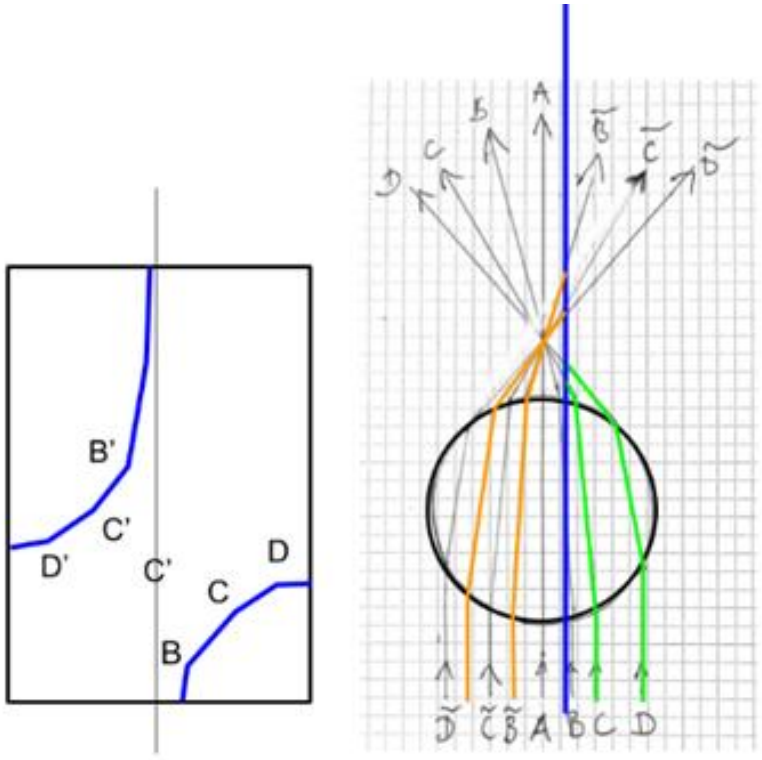
The students start doing case descriptions. Note, how their pictures are not simple reproductions of the phenomenon presentation above but show new features. They start profiling.




As default investigating strategy to examine the refraction effects of the filled glass, the learners were advised to align pencils in front and behind of it. This would allow them to determine the *directions of sight*. The pictures on the left show sight and arrangement of a centred line of sight while the two on the right depict the same for a line of sight close to the rim of the glass.



In ongoing investigation processes the first illustrations arose and served as basis for discussion (and maybe later creating something presentable). The attempt of a graphical reconstruction of the distortion of a line that leads away from the observer (left) and the top view of different paths crossing the glass and intersecting in a narrow area close to the back of the glass (right) are only some examples of possibly temporary products. As the closer segment is seen via the right half of the glass while the farer one is seen via the left half, a finger held near the crossing area (*see above*) is invisible from the other side!



8. Annex 2

8.1. Examples of moderating practices

5.2 GALLERY WALK

Goal
Discuss ideas in the team; foster ownership and commitment; encourage collaboration

Number of participants
- 4+

Time required
- 30-60 min

Materials required
- Posters with main results/analyses and/or quotes etc.
- Post-its or templates and pens for all participants

Facilitation skills required
- Basic

Further considerations
- Often gallery walks are used as a mirroring session, i.e. to play back results of an analysis. Important in this case: do not play back digested analysis with an interpretation but rather well structured raw data

Process/how it works
- Prepare: put posters around the room, either attach to wall (if possible and allowed – check beforehand) or to pin boards/meta-plan walls
- Explain the procedure: e.g., starting "We want to make this an interactive discussion rather than a presentation" (5 min)
- Ask participants to get together in couples and hand out post-its and pens. Alternatively, you can use a template which savs "what strikes me" (general observations like the employees answered the survey differently from the managers) and "what action we should take" (we ought to increase alignment between managers and employees in team)
- Ask participants in their couples to go around the room and look at the posters with the results; they should note thoughts/ comments/conclusions they draw from the posters on post-its and put them on the respective posters (15-30 min)
- Facilitate a discussion with the whole group based on what participants wrote on post-its for the different results (10-25 min)

1.1 FAST NETWORKING

Goal
Understand expectations of participants and energize participants of a workshop/event very quickly (every participant gets to talk, to move, to think); introduce topic and get people started to think about it; also, clearly creates a work atmosphere (i.e. the participants are the owners and not the facilitator)

Number of participants
- 12-25

Time required
- 20 min

Materials required
- 4 flip charts
- 1 handout and pen per participant

Facilitation skills required
- Basic

Further considerations
- Drive participants for speed and energy
- Have 3-5 questions depending on group size; ideally 4-6 people with same question
- Variation: have participants introduce themselves after presenting their flip
- Refer to insights during workshop

Process/how it works
- Prepare: Place one handout with a question each under the chair/on the table of each participant, head down (examples on next pages); prepare one flip chart in every corner with one of the fast-networking question each
- Explain the exercise: e.g., starting "We are in a workshop (stress work) here today; therefore, I would like to ask you all to stand up now" (2 min)
- Ask participants to walk around and collect as many answers as possible to the question on their handout by asking other participants in the room; if asked the same question again, think of another answer; quantity not quality counts (4 min)
- Participants with the same question (indicated by the color) are in a group; ask them to come together in front of the flip chart with that question on it and to synthesize their answers (4 min)
- Ask participants to present their findings in the plenary (1 min/team)
- Briefly comment on the findings (e.g., referring to upcoming content; if you ask for expectations, be clear what can/cannot be met (2 min)

9. ANNEX 3

9.1. Examples of feedbacking practices

Favourite Places

Short Description

A detailed map of the area of the activity is placed on a table, and participants relate the SENSE. activity to their favourite and least favourite places, placing pins on these places on the map. Participants write about the places on sticky notes, including one word or phrase about how they feel about this place or why they chose it.

Alignment with Reflective Feedback Goals

This activity explores how a SENSE. learning activity works with space, place and time through exploration of place-based connections and transformative potentials of activities, participants, communities, and local place.

This activity also aligns with:

- Sense! – using spatial proprioception and spatial thinking.
- Imagine! – identifying strong positive and negative feelings relating to the activity and place, and thinking about how different spatial settings or approaches to place could make for different futures.
- Co-produce and Act! – Co-mapping leads to negotiations, conversations and engagement, while each participant is asked to participate.

This activity also has a focus on the nature of transformation (positive and/or negative). The activity analysis could also include analysis of difference in submission.

Fully description of activity (how to carry it out)

Facilitator will print out a map of the local area from OpenStreetmap on paper (A4 size to A1 size, bigger is better), and place this map on cardboard on a table.

Participants will gather around the table and be instructed to take pins of different colours and reflect on the map in relation to the SENSE. learning activity. Participants will place pins of one colour on favourite places, and a different colour on least favourite places.

Participants will also write on sticky notes the name of a place and a word or phrase on a feeling or description of why a place was chose. Sticky notes are to be placed on a wall and the group will discuss submissions, note important places for the group, or propose actions from the activity.

Materials-based SENSE!

Short Description

In pairs, take a material that you have been working with in the activity today and apply it on to an A4 page in a way that you relate to the activity. Participants reflect on his activity on sticky notes and discuss as a group.

Alignment with Reflective Feedback Goals

This activity closely aligns with Sense!, Create!, Co-Produce!. Imagine!
This activity has a focus on the materiality of transformation, and empowerment in making change and engaging and communicating in aesthetic and scientific ways with materials available.

Fully description of activity (how to carry it out)

In pairs, take a material that you have been working with in the activity today and apply it on to an A4 page in a way that you relate to the activity. Participants reflect on his activity on sticky notes and discuss as a group.

Resources needed

A4 pages and leftover material from SENSE. activity.

Poetry, follow the rules!

Short Description

As a group, use different methods to come up with a long word or two words that relate to the learning activity. Participants will be given a short amount of time to write acrostic poems relating to their experience of the SENSE. learning activity.

Alignment with Reflective Feedback Goals

This activity closely aligns with Sense!, Make! & Create!
This activity has a focus on the reflection on the 'if' and 'how' of transformation.

Fully description of activity (how to carry it out)

Acrostic poems are a type of poems where the first, last or other letters spell in a vertical line a particular word or phrase.
All participants in the activity take time to write a short acrostic poem and afterwards, participants are invited to share their poem with the group by reading or gifting it to one other person.

For example:

Sense
Some storm is coming, and
Every moment I can feel it
Nose can smell it, ears can hear, even the toes can wiggle and feel
Soon there will be a change, I can sense it
Each rain droplet, announcing its arrival

Resources needed

Pen and paper

10. Annex 4

10.1. ID cards

Practice example - ID Card

Title	
Short description	What does this practice invite participants to do....? (max 100 words)
Key features	What is the nature of the inquiry and the task? (e.g. sensorial; artistic; logico-analytical; listening; making and design; collaborative etc.) Do you see specific starting points for reflective feedback? (... max 50 words in total)

Dimensions of SENSE.STEAM inquiry	**Select 3 key dimensions:** • Noticing deeply • embodied knowing • questioning • identifying patterns • making connections • exhibiting empathy • living with ambiguity • creating meaning • acting • reflecting • assessing

Links to the STEAM Labs: topics	Please tick	Short explanation
European Green Deal		
Health		
Digitization		
Work Readiness		
Cross-cutting areas		
Space		
Social Inclusion		

11. Annex 5

11.1. List and short description of collected practices

Practice examples to inform and shape the SENSE.STEAM methodology.

1. Young digital leaders
   Participants become digital leaders and reflect on social media and on different filters we have online and offline.
2. Drawing sounds_1
   Participants get sound out from provided or own material from day-to-day life and depict it in any way.
3. Architecture and poetry
   Participants are asked to write a cinquain poem about the space that they are in.
4. AlieNation
   Participants are invited to behave in a mannerr they are not supposed to behave where they are at the moment.
5. Empathy balloons
   Participants are asked to make a balloon bouncing in a hand while doing some digital work on their phone. This encourages users to consider the idea of cognition impairments and what effect it has on the users of digital products.
6. System Constellation
   Collaborative discussion involving role playing and sharing of perspectives.
7. Anchor senses
   Practice with 'anchor senses', making one sense less dominant.
8. Gender mainstreaming
   Participants reflect on the gender mainstreaming in their organisations.
9. Reflect and interact
   Participants confront ideas and approach in an inter-cultural environment.
10. A frame for my story
    Participants create a simple mechanical sculpture that lets them bring stories to life.
11. The Tangram puzzle
    Participants challenged themselves at translating a visual geometrical representation into words for others who can't see it in order to draw it precisely on a sheet of paper.

12. Shadow city
    Participants build a city with different materials in order to explore materials in relation to light and shadow.
13. Fast Fashion
    The practice invites participants to attempt to sew a button into a piece of fabric to practice the ability to do basic clothes-mending and to reflect on the effect of fast-fashion on the environment.
14. Water and sanitation safety planning
    Participants map the water and sanitation systems in their community identifying risks, pattern, problems and open questions.
15. Stairways to glass
    This practice invites participants to a visual encounter and aesthetic experience of a spectrum of phenomena of glass.
16. Melting ice
    Participants experiment how the ice melts in fresh and salt water.
17. Falling leaf
    Participants imagine the possible questions and outcomes starting by the experience of a falling leaf.
18. Body clock architecture
    Participants design and make a kinetic light device that takes inspiration from nature, in response to a brief about evoking emotions.
19. Shadow city theatre
    Participants make a shadow theatre with simple materials.
20. Neighbourhood of your dream
    Participants design and build models of houses and buildings, with flexibility in terms of complexity and technology.
21. Gender roles
    This activity helps participants identify the gender stereotypes and norms that shape their behaviour as men and women.
22. The shape of sounds
    Participants are invited to find ways to visualize the transformation that waves of sounds produce on matter.
23. Article from the future
    This practice invites the participants to imagine their own neighbourhood or other physical space five years from now.
24. Girls' tech
    This practice is an Erasmus+ KA2 project which aims to explore the low participation of females in STEM. The focus of the project is on technical education.
25. Drawing sounds_2

Participants generate sound from provided material or ordinary objects they carry. They are instructed to depict the various kinds of sounds they (and others) created in any way by using available or brought material.

26. In-touch
    This practice invites participants in close observation with eyes closed, challenging the common conceptions of observation.
27. Gender portraits
    This practice engages arts-based methodologies (adapted from photo-voice and collage) to generate awareness of social norms and cultural values within a group. It is inspired by the performance *Rhythm 0* by Marina Abramović.
28. A house for the fairy
    Participants are invited to build a house for a fairy, immersed in the natural environment.
29. "IL SIGNIFICATO DEI COLORI - storie dal mondo raccontate senza parole" - Wordless Stories from the World
    The practice represents a multi-sensorial exploration of the world through the exploration of the typical spices of the different countries.
30. The skin of the world
    Participants take part to a multi-sensorial exploration of the surfaces of the physical world, starting from participants' own skin. Inspired by artist Hundertwasser.
31. It is a matter of state
    The practice is a science-related dance performance about the three states of matter - Solids, Liquids & Gases.
32. Favourite Places
    Participants are invited to place pins on a large basemap on their favourite places and least favourite places, and discuss, reflect and write about feelings, thoughts and ideas attached to these places.
33. D.I.N.E
    Participants are invited to choose the desired ingredients to create a dish/art installation that represents their personality, cultural background, and aesthetic view.
34. Reclaiming our bodies
    Participants are invited to represent their body through emotional associations, rather than realistic representations.
35. Science and language
    Participants reflect on language and rearrange the description of phenomena and events through a new linguistic style.
36. Heart Healthy foods project - Photovoice
    The practice is a creative and articulated manner to involve a community and work together, using photographs taken and selected by participants.

37. Zooniverse – Crowdsourcing
    This practice has the platform is the world's largest and most popular digital resource for people-powered research that allows anyone to contribute to real academic research.
38. xAire - Low cost sensing
    This practice represents a large-scale air quality monitoring in Barcelona that was performed during one month. It is an unprecedented Citizen Science project that involves schools and families.
39. CoAct For Mental Health - Lived experiences
    This Citizen Social Science practice investigates mental health social support through a co-created chatbot, the first one used for a Citizen Science research.
40. The Florence Experiment
    This site-specific practice jointly devised by artist Carsten Höller and scientist Stefano Mancuso is an experiment combining art and science to study the interaction between plants and human beings.
41. Bridges
    This practices focus on a specific socio-ecological dimension of the current global health crisis – the fertility of soil. It encourages the coming together of people who may hold different forms of knowledge and skills as well as different experiences of working with soil.
42. Traveller Community Mapping Coolock StoryMap – Mapping
    This practice depicts the stories and memories of three generations of Irish Travellers, an historically disadvantaged ethnic minority in Ireland, about particular places in their home of Coolock, north Dublin. This project involves the use of maps.
43. FeederWatch – Observation
    The practice is based on the joint effort to broadcast bird feeders from any place on the planet. Participants are invited to be involved by installing the feeders and the live cameras.
44. Mercè - Mapping
    This practice is a citizen science experiment that involves citizens in training an algorithm to help the design process of more livable cities.
45. Safecast - Low cost sensing
    This practice allows the citizens to monitor, collect, and openly share information on environmental radiation.
46. Public Lab - Low cost sensing
    This practice uses collaborative, open source environmental research in a model known as Community Science. It supports communities facing environmental justice issues.
47. Citizen Science Toolkit for teachers - Co-creation and Co-design

This practice involves citizen science research projects that were collaboratively designed with the students in three schools of Barcelona Metropolitan Area, through a co-creation process.

48. Citizen Social Science Toolkit - Co-creation and Co-design
    The Toolkit is an open resource that provides practical and technical information on the citizen social science methods that CoAct (see 39) co-researchers applied in their projects.
49. Chromoculture - Co-creation and Co-design
    The practicet involves the creation of a garden-laboratory specialising in natural dyes for the textile, ceramics and publishing workshops of the art school, combining various methodologies.
50. Dissect - Research-creation and Co-design – Performance
    The practice involves the creation of innovative devices for dissemination and sharing of multidisciplinary research-creation.
51. Daoula / sheen - Co-creation and Co-design - Ethnography – Curation
    This multidisciplinary practice combines different scientific expertise and vernacular knowledge in the framework of a museum-driven programme, whose research results are translated into an exhibition format.
52. Mise en corps technique – Dance
    This practice represents an innovative dance-based pedagogical project aimed at integrating sensitive bodily experience and technical knowledge to address gestures and embodied knowledge in all its dimensions.
53. Campus Louvre Nocturne with Paris Saclay - Scientific mediation in art museum
    The practice proposes a different mode of cultural mediation, reorienting the public's attention and proposing a scientific re-reading of the artworks.
54. Le savoir-verre. Capturing Craft - Co-creation - Co-design – Etnography
    The practice is a restitution of a multidisciplinary research on the intangible aspects of heritage, through an interactive installation that recreates the gestures and sensations of glassmaking.
55. The Art of Letting Earth Speak - Research-creation – Ethnography
    This research-creation practice aims to develop, through artistic devices, a shared narrative of traditions and knowledge in the field of horticultural and agricultural practices.