SENSE. The New European Roadmap to STEAM Education

D4.4 – Recommendations for the Roadmap and Learning Companion

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Abbreviations and acronyms

Abbreviation or acronym used in this document	Explanation
STEAM	Science, Technology, Engineering, Arts and Mathematics

Glossary

Term	Definition used or meaning in the SENSE. project	Reference if applicable
Implementation Activity	Implementation Activities are any activities carried out by the STEAM Labs that implement the unique SENSE. methodology. The project's implementation activities in the labs reach potential change agents and enable them to become advocates for STEAM.	D3.1
Learning Sequence	A *learning sequence* refers to an activity of a STEAM Lab that focuses on communicating, teaching, or researching a topic or issue (in whatever form). In this context, characteristic *practices* are used, that involve, activate, or inform participants and can be content-centred, teacher-centred or equally focus on social interaction or refer to open learning environments.	New: Chapter 5.1
Roadmap	Roadmap is a strategic planning technique that helps to communicate to all the stakeholders of STEAM education the SENSE. project's goals, and their respective major deliverables over time which also supports them in defining their respective action plans. It is a step-by-step process for providing an implementation for future STEAM education. There are three phases of the Roadmap: Awareness, Action, and Advocacy.	D2.3

SENSE. / SENSE. project	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.	D3.4
SENSE. stakeholder	A stakeholder in the project SENSE. is any person, organisation or group that is affected by or who can affect the outcomes of this project.	D3.3
SENSE. methodology	The SENSE. methodology, comprising a dedicated educational model and its pedagogy, with i) STEAM inquiry, ii) citizen science and art practices, iii) learner centredness and iv) reflective feedback as its building blocks	D1.1
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.	D2.7
STEAM Lab	A specialized learning environment for the implementation of SENSE., featuring diverse participant panels and addressing specific needs in varied social, cultural, geographical, and economic contexts.	D7.2

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., 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 is the result from the Task 4.4; recommendations for the Roadmap and its learning companion, led by the project partner HVL, and in collaboration with project partner UEdin, planned for, and conducted during the Months 24-26 of the project implementation. Based on their series of activities and events at each of the SENSE. STEAM Labs, and the data collection and evaluation, inputs and recommendations have been collected for each step of the Roadmap and on the learning companion as the core element of the roadmap.

In preparation of this deliverable and based on the report on implementation activities of the STEAM Labs, prepared by PHW, as well as the report on SENSE. evaluation of the four policy areas, prepared by UEdin and HVL, as well as the policy recommendations from WP5 and WP6, a set of key recommendations from the implementation activities and the cross-cutting issues were drafted by UEdin. This was followed by drafting the set of recommendations for the roadmap and the learning companion by HVL, in harmony with the initial outline of the roadmap delivered by HVL about a year ago.

Accordingly, the document comprises of three main parts, including a summary of key findings from the WP4, WP5 and WP6; recommendations for the learning companion – including recommendations for curricula development at the education system level as well as curricula deployment at the school level; and recommendations for the consolidated SENSE. roadmap to STEAM education.

When it comes to the key findings from the implementation activities and the cross-cutting issues space and social inclusion, among other things, the deliverable at hand points to flexibility and adaptability of the SENSE. methodology across the labs, resulting into re-engagement of participants with STEAM learning, re-activation of their sense of agency and role in tackling key societal challenges, as well as the necessity of expanding the learning space beyond formal institutions, and adaptability of classrooms as spatial bedrock of STEAM learning. These are seen pre-requisite for providing multiple entry points compatible with variety and diversity within and across target groups at various societal levels.

Concerning the recommendations for the learning companion, and building on the mentioned key findings from the implementation activities, the document points to the key principles central to the design and implementation of STEAM-based content across education system, such as the role that human senses can integrally have in developing scientific qualifications of learners, collaborative deployment of STEAM curricula through networked education and open schooling, and the cruciality of access to supportive and explorative spaces for upskilling of learners.

Finally, the document contains recommendations for raising awareness about the SENSE. approach's advantages through its motivational, methodological, and societal merits. This is supplemented with suggestions on revisiting the development

of integrated STEAM content, and relatedly, teacher education methods, to reap the advantages foreseeable from the uptake of the SENSE. approach. Lastly, suggestions are made regarding advocacy for the project's proposed approach through networking and establishment of a lasting interaction infrastructure.

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1. Introduction

The SENSE. Project aims to provide a roadmap for *STEAM education* in Europe, an approach to learning characterized with process-based takes on ontology of natural phenomena. Hence, the SENSE. Project itself is also basing its roadmap development on extracting the components of the roadmap from the lived experiences about learning across the 13 SENSE. STEAM labs established throughout the project term. Accordingly, and concomitant with the conclusion of the evaluation of the implementation activities (D4.3), this deliverable provides a set of recommendations for the design of the consolidated roadmap and its core element, the learning companion, derived from the observations made during the implementation activities, and the concomitant study of cross-cutting issues space and social inclusion over that period.

1.1. Purpose of the document

This document aims to provide a set of recommendations for the design of the consolidated SENSE. Roadmap, as well as its core component, i.e. the learning companion, based on the experience gained from implementation of SENSE. across the 13 Labs involved in the project.

1.2. Intended readership

This deliverable is first and foremost intended to inform the SENSE. Project partners developing the learning companion as well as the consolidated SENSE. roadmap through the recommendations provided in the document. Nonetheless, it can also be used by all interested parties who would like to review a summary of findings from the SENSE. implementation activities along with the implications from the cross-cutting issues space and social inclusion.

1.3. Structure of the document

This document comprises three main parts, including a) a summary of key findings from implementation of SENSE. across the SENSE. STEAM Labs; summary of findings regarding the cross-cutting issue space; and a summary of findings regarding the cross-cutting issue social inclusion; b) recommendations derived from the mentioned findings for the design of the learning companion; and c) recommendations derived from the mentioned findings for the consolidated SENSE. roadmap. These are wrapped up with a conclusion section.

1.4. Relationship with other deliverables

This deliverable is informed by the reports on implementation of the SENSE. STEAM Labs, i.e. D4.2 (Report on the implementation activities of the STEAM Labs) D4.3 (Report on the evaluation of the four specific areas), as well as the policy recommendations from the work-packages on cross-cutting issues space and social inclusion, i.e. D54. (Policy recommendations: STEAM spaces and the New European Bauhaus) and D6.4 (Policy recommendations: social and gender inclusion). It is furthermore informed by the initial outline of the SENSE.STEAM Roadmap, i.e. D7.1 (First outline of the New European STEAM Education Roadmap).

This deliverable provides input to the consolidation and implementation of the SENSE. Roadmap, through informing deliverables D7.3 (First version of the digitized educational materials and toolkits), D7.4 (Report on the two real-world applications of the Roadmap), and D7.5 (The New European STEAM Education Roadmap).

2. Summary of findings from the implementation activities and cross-cutting issues

2.1. Key Findings from Implementation and Evaluation of STEAM Labs (WP4)

1. During implementation of the STEAM Labs, SENSE. proved to be a flexible and adaptable methodology which addressed participants' needs across different contexts. The variety of stakeholders involved evidenced the adaptability of the SENSE. approach, and how it significantly overcomes institutional elitism even in one-off events.

2. Activities were designed to be creative, open-ended, and unique to context including place, community, time and the people and institutions involved. Different methods were used to activate and to integrate different senses and ways of working, while the participatory process was key to interpret and to make sense together of what had happened.

3. Key to all the activities was a long-standing effort to go beyond the privilege associated with formal institutions like the academy, and engage with local municipalities on the ground, build relationships of trust with participants, with teachers as well as children and their parents, and work closely with marginalized groups in society.

4. In some of the Labs, the SENSE. approach to STEAM was deployed to target key issues such as health, poverty, wellbeing; participants were engaged directly through both arts and sciences to impact public perception and redirect policy priorities for teacher preparation.

5. The activities proved effective in re-engaging participants with the world of education and gaining the confidence to play an active role in society. The emphasis was principally on participation, particularly in contexts of high levels of material deprivation and youth disaffection.

6. Creative methods for co-evaluation like mapping and portraits helped to build participants' reflective consciousness of their role in their local environment, how to pay attention to things that are important for them, and towards which they could direct efforts for change.

7. The evidence from the visual data (body portraits) showed that the senses proved to be an accessible way to develop technical as well as imaginative competences, thus closing the gap between schools and the world of work, as well as between the academic and the vocational.

8. There was recognition from stakeholders about the need to make times and spaces for SENSE. initiatives a legitimate part of their education, for example through reforming school schedules to free up students in the afternoon to engage with artistic and social activities or re-inventing the role of civic spaces such as libraries, to welcome the activities of the youth.

9. Building on participants' reflective consciousness of their role in their local environment, the SENSE. approach was used to effect actual, physical changes in the outlook of their communities, for example through direct actions such as gardening, advocacy, and collection of data to present to policymakers.

2.2. Key Findings from Cross-cutting Issue of Space (WP5)

1. All Labs engaged actively in thinking about the physical environment and its impact on the activities. A general increase in ratings of four dimensions ("Appearance", "Environment", "Space", "Function") between pre- and post-activities showed a rising awareness and recognition of the relevance of the physical environment for the SENSE. approach.

2. The most common spatial typologies used in the Labs were outdoor spaces and adaptable classrooms with flexible furniture. This adaptability and flexibility represented the spatial bedrock of STEAM education. Familiar appearance ("sense of belonging") and spatial flexibility were rated highly by most of the facilitators.

3. The partnership between world of work and world of schools through SENSE. showed the importance of space playing a significant role for learning; not simply in terms of infrastructure but most crucially as an element that is fully integrated into the making process itself.

4. Space promoted tri-dimensional thinking (important for Work Readiness) and movement (important for Health and Green Deal). This finding contributes to greater understandings of space in education and how SENSE. widens the range of opportunities for all stakeholders to learn beyond the classroom.

5. While all partners managed to find spaces to undertake the activities, it was clear that the formal educational spaces in schools and universities were largely at odds with their needs. Hence, both time and spaces for people to meet, feel comfortable and work freely were important considerations.

6. Using the experience gained from the STEAM Labs, two overarching categories were developed – "supportive" and "explorative" spaces. While a "supportive" space creates the right conditions for a STEAM activity, an "explorative" use of space turns the physical environment into a purposeful tool to achieve STEAM-specific objectives.

7. Spatial evaluation of the STEAM Labs (D5.2) led to the creation of a "Spatial Self-Experience Kit" (D5.3), replacing the four dimensions with

a set of targeted questions and collection of spatial STEAM patterns as an inspiration for the SENSE. roadmap users. The aim of the Kit is to raise awareness for the spatial conditions of STEAM education and inspire a wide range of stakeholders to engage more actively and experimentally with their physical environments, increasing spatial literacy and agency.

2.3. Key Findings from Cross-cutting Issue of Social Inclusion (WP6)

1. The Labs engaged in self-reflection exercises based on individual, community and society levels that strongly correlate when considering social inclusion, gender, and intersectionality. The Labs were also guided by a set of points addressing practical aspects of considering social inclusion, recognizing the need for tailored strategies based on local contexts.

2. This transformative approach was aimed at shifting from passive assimilation to active engagement and dismantling exclusionary norms, ultimately leading to a more just, equitable, and inclusive STEAM education. Each Lab included a needs assessment that focused on the physical, social, and intellectual needs of participants.

3. The process of self-reflection encouraged facilitators to think and rethink the activities they were developing, and to see themselves within the activity throughout the process. It allowed for multiple entry points into STEAM for participants, with their interests, inclinations, and talents taken as a starting point for the activities, while drawing on experiences and knowledges in the local community.

4. Applying the self-reflection exercise across multiple levels of society was found to reveal contextual nuances while orienting Lab facilitators to ask themselves questions of the local environment, city, country, and culture. This process revealed scalability and applicability of activities in relation to a multiplicity of contexts and situations.

5. Activities in the SENSE. project learning sequences showed high engagement of all students, highlighting the importance of ensuring that all approaches are based on learners' needs and interests, instead of imposing mandatory curricula.

6. The SENSE. approach was found to create pathways to social inclusion and gender justice, supporting a variety of educational possibilities for pupils through sensory and embodied engagement and experience.

7. Evaluation of aspects of social inclusion through the led to the development of the "Social Creativity Toolkit" (D6.3). The core of the Toolkit is self-reflective, viewing social inclusion and social creativity as ongoing efforts rather than fixed achievements. The Toolkit frames the approach to self-reflection through a series of questions, first centered on the themes of Consider. Reflect. and Sense., and then asking four questions "Why, Who, What, Where" across three societal levels (individual, community, society).

3. Recommendations for the Learning Companion

The learning companion aims to "support the adoption of SENSE. through a freely configurable, modular structure, whereby curriculum content plays on the bandwidth of the senses" (SENSE. Project Description of the action, Part B, p. 13). Considering the above-mentioned key findings from the implementation activities across the SENSE. STEAM labs, as well as the cross-cutting dimensions social inclusion and creativity as well as space, we propose the following recommendations to be considered in the development of the SENSE. learning companion.

3.1. SENSE.STEAM-based curriculum development at the national level

1. For addressing the grand societal challenges that world in general, and Europe in particular is faced with, national education systems can benefit from further promotion of learner-centered approaches to education, based on which the learning process originates from the learners' perceptions about, and interactions with, the world around them and the learned subjects. This can entail further prioritization of phenomenon-based (as opposed to subject-specific) learning in the planning of vertical curricula along the education.

2. This learner-centered approach has various structural and processual implications for the renewal of education systems in Europe in general, and STEM/STEAM education in particular. First and foremost, the educational content perse, and relatedly, the epistemic and methodological dimensions of the educational content require further enrichment by process-based learning (as opposed to concept-based learning) which allows for the uptake of learner-centered pedagogical approach. Process-based learning strengthens human sense-driven and self-initiated acquisition of knowledge, thereby promoting agency and active participation of learners in understanding, processing, and resolving real world issues.

3. The phenomenon-based approach to STEM/STEAM education can prepare learners for undertaking problem-based approaches to learning and skills acquisition during the latter parts of their education. This, in turn, facilitates transition to the world of work. All these observations call for opening up the (formal) learning environment to establish better connections to informal, non-formal as well as vocational learning environments, where "supportive" and "explorative" spaces for STEAM-based upskilling are more easily at learners' reach.

4. The active learning and engagement environment provided to learners through combining the above-mentioned types of milieus can be expected to serve variety of needs that learners with different interests, backgrounds, and talent can have. This not only improves the possibility for inclusive education, but also opens new opportunities for integration of educational, professional, and social life skills. This calls for further modularization of educational and didactic offers along the vertical curricula over the years of schooling, based on which learners can exert more agency in shaping their own educational path.

3.2. SENSE.-based curriculum deployment at the school level

1. As the formal environment for education and learning, schools need to open up for collaborative deployment of STEAM curricula together with other entities in the educational network, such as museums, external workshops, galleries, laboratories, NGOs, and many more societal entities which have the capacity for involvement in the learning continuum. This requires early involvement of those informal, non-formal and eventually

vocational environments in the planning of the educational activities around STEAM curricula deployment. Nevertheless, the flexible modularization of the curricula can provide possibilities for a more adaptability of the annual educational plan to the learners' tendencies emerging over time during the year.

2. Internal organizing and arrangement of school spaces themselves need to be further adapted to the requirements of process-based, individualized, and networked learning experiences. These considerations are essential to activating learners' agency in the STEAM learning process and should be considered during design and renewal of schools' physical spaces.

3. Human senses, as the first and most influential medium between learners' cognitive formation and the objective world, have central role in developing the ontological and epistemological qualities of STEAM learners. Accordingly, various dimensions of schools' physical spaces (appearance, environment, space and function) need to reflect compliance with adequate development and exploitation of capacities available to the senses.

4. Recommendation for the Roadmap

In this part, recommendations for the roadmap are provided based on the three overall steps foreseen for it, namely: awareness, action, and advocacy.

4.1. Awareness

1. It is essential for the SENSE.STEAM Roadmap to elucidate STEAM approaches' advantages in terms of motivation for learning, methodological merits, inclusivity of the approach, nurturing creativity, as well as practical advantages such as work-readiness and closer contact with real world issues and clearer perception about, and handling of the materiality of the societal challenges.

2. The SENSE.STEAM Roadmap needs to emphasize the relevance and importance of participatory practices across the STEAM learning continuum, from the micro-cosmos of a single phenomenon observation and interpretation to the meso-cosmos of curricula

deployment through inter-institutional collaborations, and up to the macro-cosmos of curricula development at the (national) system level, where there is need for informed amendments of regulatory frameworks around facilitation of networked learning infrastructures and inter- and transdisciplinary content developments.

4.2 Action

1. The SENSE.STEAM Roadmap needs to highlight the crucial role that teacher education in general, and teacher education around STEAM-related fields in particular will have on the implementation of the SENSE.STEAM approach at schools and wider spheres. This will have important implications for the pedagogical aspects of teacher training, as well as the way teacher training is organized at higher education institutions. Implementation of these changes pertain to the system-level changes that would eventually entail administrative and regulatory changes at the national education system.

2. Introducing interdisciplinarity and transdisciplinarity, for instance through art infusion or arts integration with the STEM fields, are at the core of STEAM approach to education. Accordingly, implementation of STEAM approach in didactic practices would require developing interdisciplinary and transdisciplinary didactic material based on which learners and practitioners can use their human senses in simultaneous comprehension and enjoyment of the artistic as well as scientific qualities and principles. In this regard, the SENSE.STEAM Roadmap needs to develop the learning companion with adequate clarity and informativity on the proven practices in representing an integrated and inter- / transdisciplinary STEAM learning material.

4.3 Advocacy

1. The SENSE.STEAM Roadmap needs to be equipped with a lasting and expandable infrastructure to increasingly engage new actors of various type who have interest in learning and educational practices around STEAM-related topics. The experience from the SENSE.STEAM labs proved that events and entities dealing with contemporary and pressing societal challenges represent some of the most fertile grounds for promoting the STEAM approach to knowledge and skills

acquisition, participatory interpretation and problem solving. Accordingly, the roadmap can ideally establish a channel for identification and interaction with communities dealing with citizen science and active citizenship around pressing societal issues at local scales or beyond.

2. SENSE.STEAM Roadmap should support establishing interactive linkages with other existing platforms around STEAM education, specifically aimed at making synergy with them. For instance, the toolkits developed on space evaluation and social creativity by the SENSE. Project represent some of the specific fields of attention that can support other STEAM learning and practice initiatives. These can provide opportunities for further enhancement of the toolkits through scaled implementation and appraisal of the SENSE. Toolkits.

5. Conclusions

Implementation of the SENSE.STEAM activities (practices) across the SENSE.STEAM Labs over the past 2 years has provided us with a collection of experiences and insights regarding STEAM-based education and training, according to which the overall direction of our SENSE.STEAM Roadmap and its core element, i.e. the learning companion can be determined at this stage. Drawing on the key findings from the implementation activities, accompanied with insights gained about the cross-cutting issues space and social inclusion and creativity, this document has come up with recommendations to be taken into consideration when designing the SENSE.STEAM learning companion and the ensuing Roadmap.

In order for the Roadmap to be widely adoptable at multiple scales and contexts, we aim for a modular and flexible structure based on which variety of stakeholders and interest groups can adapt a desired set of components from the Roadmap. Nevertheless, we believe that curriculum development at education system level, and its deployment at the school level would need to accommodate learner-centered, open, and networked, process-based and phenomenon-based approaches to learning in a more systematic way than currently is the case across Europe. Adequate design of educational, or more generally, didactic spaces play a crucial role in this respect, which further calls for awareness and action at the education system level for intervention to promote and cater for STEAM-based learning environments. This needs also to

be accompanied by revisiting educational material as well as teacher education methods to scale up the advantages that STEAM learning can have regarding a more inclusive and attractive learning- and work environment around the STEM fields in Europe.

6. References

European Commission (2022). SENSE. Project: Description of Action – Part A
European Commission (2022). SENSE. Project: Description of Action – Part B