SENSE. The New European Roadmap to STEAM Education

D7.1 - First outline of the New European STEAM Education Roadmap

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Abbreviations and acronyms

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

Glossary

Term	Definition used or meaning in the SENSE. project	Reference or source for the definition if applicable
Design process	A process to guide understanding of design issues and effective communication of solutions.	www.designcouncil.org.uk
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	NA
STEAM labs	A specialized learning environment for the implementation of	D4.1

	SENSE.STEAM, featuring diverse participant panels and addressing specific needs in varied social, cultural, geographical, and economic contexts.	
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 Stakeholder	STEAM stakeholders encompass a broader range of entities such as students, companies or 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.	D3.3

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 STEAM 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

The current deliverable presents a report on Task 7.1 of the SENSE Project. The objective of the task is to create a preliminary draft of the New European STEAM Education Roadmap. The document lays the foundation for the roadmap's development during the project duration by outlining the essential principles of the SENSE.STEAM strategy for multi-stakeholder STEAM education development across the near-to-long term. It refers to the workshop on the roadmap activity held during the project consortium meeting in October 2023 in Tbilisi. During the workshop, project partners engaged in a design activity to establish core guiding principles for multi-stakeholder collaboration around STEAM.

The workshop results highlight the roadmap's flexibility and openness to personalisation, considering the significance of human senses and art-based practices within the STEAM educational approach. In essence, the comprehensive plan outlined in the document acknowledges the significance of multi-tiered systemic endeavours, such as the creation of integrated STEAM teaching methodologies and the coaching of STEAM instructors, as critical benchmarks for the long-range growth and execution of the novel educational scheme. Nevertheless, it is vital to preserve the roadmap's fundamental nature, which capitalises on the instinctive human sensory perception and the resulting ingenuity, for the roadmap's continuation.

Accordingly, this deliverable progresses from the previous project work connections to the roadmap's strategic implications for the STEAM didactics stakeholders' constellations and the levels at which the roadmap's components can be developed and tested as action plans. Since it is only an initial draft of the consolidated roadmap, it is expected to evolve over the SENSE term. Through the implementation of the roadmap in chosen STEAM Labs, the tool will be enhanced, evaluated, and validated, in readiness for its inclusion as input into the ultimate roadmap of the SENSE project.

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1. Introduction

This report details the fundamental steps, informed by both theoretical and practical research, to form the first outline of the SENSE. roadmap to STEAM education in Europe. The roadmap will show pathways where STEAM education is an accessible, inclusive and gender-just continuum for engaging with STEAM, resulting from the joint efforts of the SENSE. consortium, associate partners and various STEAM stakeholders. In the following sections we share our conceptual baseline, explorative work and emerging strategies that mark the inception of a comprehensive roadmap shaping the future of STEAM education across Europe.

1.1. Purpose of the document

The first outline of the New European STEAM Education roadmap serves as the basic framework for a comprehensive and strategic tool to promote science, technology, engineering, arts, and mathematics (STEAM) education across Europe. This initial blueprint outlines the key components, methodologies and priorities that will shape the development of the roadmap. It aims to provide a structured overview of the scope of the roadmap, highlighting its importance in fostering innovation, collaboration and the development of essential skills and abilities among learners. The purpose of this preliminary outline is to provide a clear trajectory for the subsequent stages and to guide the collaborative efforts of stakeholders, researchers and educators in the pursuit of a transformative STEAM education landscape in Europe. This first outline shall also function as working document for closer collaboration with other initiatives, including the projects funded under Horizon Europe, HORIZON-WIDERA-2021-ERA-01.

1.2. Intended readership

The audience for this first outline of the SENSE. roadmap for STEAM education in Europe is diverse and encompasses a broad range of STEAM stakeholders. Primarily, education professionals such as teachers and administrators can access practical ideas on implementing the SENSE.STEAM approach that offers learner centred and meaningful activities and empowers students to meet future challenges and opportunities. Business professionals and industry leaders can also gain valuable insights into the evolving landscape of STEAM education and its impact on skills development. Furthermore, the general public, including parents and supporters, need to understand the opportunities of a STEAM roadmap, particularly in the context of lifelong learning, and can understand the importance of STEAM education in shaping future opportunities across generations. Policymakers can use valuable recommendations to lead educational policies that cater to a rapidly evolving Europe. Additionally, this plan aims to provide a comprehensive guide that caters to a wide range of individuals interested in enhancing STEAM education. Last but not least, we

aim to utilise this initial overview as a starting point for working together with the other two roadmap initiatives that have received funding under call Horizon Europe HORIZON-WIDERA-2021-ERA-01.

1.3. Structure of the document

In Section Two, we present the fundamental concepts that support our creation of prospective paths towards the SENSE. roadmap for STEAM education. Our approach is grounded in the methodology described in the project's action plan, alongside the most contemporary theoretical framework published by Ilevbare (2023) for Joint Research Centre's EU Policy Lab series.

In Section Three of this document, we will showcase a pragmatic method for visualising the SENSE. roadmap. Our consortium partner, Velvet, led us through this process during a fruitful work meeting in Tbilisi in October 2023.

In Sections Four and Five, we will analyse how the forthcoming project activities will build on the achievements outlined in this publication.

1.4. Relationship with other deliverables

This report is linked to all the previous achievements of the project. It is also the baseline for consolidating and linking all future efforts to create the SENSE. roadmap to STEAM education. As such, this first outline of the Roadmap is to be set within the broader project framework, with critical interdependencies with various deliverables from previous and concurrent work packages.

The roadmap builds on the foundational blueprint of WP3 which is based on extensive research, collaboration, and reflection. WP4 will contribute with findings from the implementation of what was developed in WP3, including a learning companion and impact evaluation. The evaluation of the implementation of the STEAM educational designs will be accompanied by the development of stakeholder communication and networking, including local networks and EU/Erasmus initiatives. Future valuable inputs from work packages 4, 5 and 6 will enrich the roadmap with diverse stakeholder knowledge, toolkits, and policy briefs. Linking the products and outputs of WPs four, five and six ensures a seamless alignment with the overarching objectives of the project.

The alignment of the outputs from WPs four, five and six with the SENSE.STEAM methodology established in WP three, culminating in the SENSE.STEAM roadmap, is a key outcome and a direct result of the future work of the project. This integration promotes an integrated approach to STEAM education and increases the effectiveness and relevance of the roadmap.

2. Points of departure

Before implementing the educational elements of SENSE., we collected strategies and procedures by studying relevant literature and our past experiences. SENSE. prioritises involvement and co-creation with STEAM stakeholders, progressing from raising awareness to motivating practical responses and backing future initiatives (see D3.3). Our goal is to combine this approach with a theory-based and practical method. This will motivate people to act and support future initiatives.

2.1. Background

In our effort to shape the future of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education in Europe, the SENSE. project set off to develop the roadmap based on three fundamental principles: Awareness, Action, and Advocacy. Our approach's cornerstone is comprehending the communities' necessities, crossing cultural and geographic disparities. Through an in-depth exploration of the challenges confronted by diverse stakeholders, we strive to communicate information in a language that resonates with them, thus fostering inclusivity and relevance. The implementation of effective STEAM education within organizations requires impactful actions, which we facilitate through the development of educational materials that are specifically geared towards empowering and supporting these STEAM stakeholders. This approach stresses the importance of prioritising actions and constructing entry points to enable the perpetual development and co-construction of educational practices. Moreover, advocacy assumes a crucial function in galvanising communities, promoting collaborative thinking and active participation to propel social transformation. We advocate for co-creation and the democratisation of STEM and STEAM knowledge, leading to a model of STEM education that values the arts as an equal partner. This approach opens up opportunities for a comprehensive, sensory and phenomenon-based STEAM education across the entire learning spectrum, going beyond conventional science education. We endorse a model that caters to a wide spectrum of stakeholders, from supporting experienced scientists to promoting advancement in local communities and families, facilitating socially aware, democratic, and scientifically literate citizens. Our methodology specifically targets the dismantling of gender stereotypes within STEM disciplines and integrates spatial design. Consequently, we explore the complex interdependence between space, social inclusion, and STEAM education. By combining science education with broader fields like architecture, urban design, environmental ethics, digitisation and socially responsible innovation, our method creates a sturdy structure that is adaptable to a diverse array of contexts throughout Europe. This approach paves the way for transformative changes across the educational landscape.

SENSE. The New European Roadmap for STEAM Education will lead interested organisations and individuals through an 8-step plan, breaking down complex ideas into smaller parts where necessary. The table below displays the defined steps that were created during the proposal preparation phase, outlining the planned content that will be provided to STEAM beneficiaries to progress from one step to the next. Additionally, the table presents the overall methodology that will be used to deliver the planned content. The language used is professional and avoids the use of colloquialisms or casual language to maintain formality.

	Steps	Roadmap planned content
1	Awareness: What is STEAM education?	Mapping of Education practices, art practices and citizen science activities related to STEAM
2	Awareness: What does STEAM education mean for me and my organisation?	Providing evidence-based information on the added value of STEAM education with practical examples from education, research and business, as well as assessment tools for stakeholders to identify implementation strategies and evaluate the impact of SENSE.STEAM.
3	Awareness: STEAM for a future-making Europe?	Demonstrating the Added Value of STEAM in Addressing Four Societal Challenges (Green Deal, Digitisation, Health, Work-Readiness).
4	Action: What educational model and pedagogy for STEAM?	Implementing the SENSE.STEAM methodology entails a distinctive education model and pedagogy that encompasses conceptual, sensorial, and enactive aspects. This innovative approach rests on four core components introduced in the SENSE.STEAM methodology that guide transformative STEAM education practices.
5	Action: How to move from the educational model to practice?	To narrow the divide between academic theory and real-world application, we suggest creating an easy-to-use Learning Assistant featuring demos and a manual, guaranteeing a smooth switch and simple instruction for both teachers and students.
6	Action: How to apply and evaluate SENSE.STEAM	Implement and evaluate SENSE.STEAM using proven approaches tailored to diverse stakeholders to guide them in increasing awareness, taking meaningful action, and promoting STEAM education within their communities.
7	Advocacy: How to promote STEAM?	Promote STEAM through the STEAM Academy and STEAM Labs, linked as a network through the digital hub. These hubs offer in-depth information, crucial tools, and policy suggestions for effectively implementing the STEAM roadmap, resulting in better integration between European Education and European Research Areas.
8	Advocacy: How to engage with other STEAM actors?	Promote engagement with other STEAM participants through the collaborative platform of the STEAM Academy and STEAM Labs, interconnected through the digital hub within an open community framework. This endeavour encourages networking, exchanging knowledge and experiences, and peer learning, augmenting partnership among STEAM stakeholders.

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

2.2. What actually is a roadmap?

Key characteristics of a roadmap

A roadmap is a strategic planning technique that places a project's goals and major deliverables, such as tasks and milestones, on a timeline. It is important to be precise, concise, and formal when creating a roadmap, and to choose appropriate vocabulary that is widely understood. Grammatical correctness, such as correct spelling, is also essential.

Since the 1960s, roadmaps have been used as a strategic planning tool to support communication and consensus among key stakeholders in an organization, industry, consortium, sector, or nation. The primary function of roadmaps is to communicate a vision, key resources, and essential steps required to achieve that vision. As such, they blend elements of explorative or normative foresight with action planning.

Roadmaps usually encompass several strategic layers, with the three most crucial being: (Ilevbare, 2023):

The 'Why' layer of the roadmap which establishes the reasoning behind the rest of the plan, identifying a present or future requirement, obstacle, or trend that represents a strategic problem for the system.

The 'What' layer of the roadmap which identifies the key strategic initiatives and deliverables that offer a solution to address the strategic issue identified in the 'Why' layer.

The 'How' layer of the roadmap specifies the necessary resources and capabilities required to carry out the initiatives and achieve the deliverables highlighted in the What layer of the roadmap.

Usually, roadmaps include a time element that answers the ‘When’ query of the plan. This means that the roadmap indicates the current position of the system in achieving the vision and how it intends to achieve the milestones in the near-, medium-, and long-term towards the final objective. Nonetheless, updating is considered a valuable feature of good roadmaps since the assumptions and predictions made during the road mapping process may prove to be somewhat inaccurate.

"Fast-start road mapping" is widely recognized as the most effective approach for initiating the road mapping process. This approach includes road mapping workshops that are integral to the process. (Ilevbare, ibid). During the workshop, a stakeholders group identifies a list of prioritised topics, such as key assumptions, drivers, and limitations. This list is then used by expert groups to conduct an in-depth exploration.

The SENSE. roadmap to STEAM education in Europe

Within the SENSE. project, our goal is to ensure that the SENSE.STEAM methodology for STEAM education is comprehensible and available to a wide range of stakeholders, encompassing individuals and organisations alike. Consequently, the SENSE.STEAM Roadmap has been designed as a tool that can be utilised by users at all levels,

including educators, schools, networks, industries, sectors, as well as national or international (European) education systems. The roadmap is designed to have flexibility for future updates and adaptations. As such, the SENSE.STEAM roadmap will feature a modular structure to enable users to combine elements based on their stakeholder's type and requirements.

Also, during proposal preparation, we drafted an initial design of a roadmap, which includes the following eight steps: 1) Defining STEAM education; 2) Explaining the significance of STEAM education for organizations; 3) Demonstrating the benefits of STEAM for societal issues; 4) The STEAM educational model and techniques; 5) Applying the STEAM educational model; 6) Executing and evaluating the SENSE.STEAM elements; 7) Boosting STEAM via the STEAM Academy and Labs; and 8) Collaborating with other STEAM participants. (see section 2.1)

Taking into account these factors, we envision the SENSE.STEAM roadmap to align with the three previously mentioned roadmap layers in the following way:

The 'Why' layer: This layer concerns the *human perceptions, skills, knowledge, and capacities* needed for acting as *conscious agents* of the society in tackling of the societal challenges Europe is faced currently and in the future. More specifically, individuals, groups or organisations intending to undertake the consolidated SENSE.STEAM roadmap make sense of the implications emanating from the likes of Green Deal, digitisation, healthcare, and work-readiness for their STEAM-related agentic functionalities in their multi-scalar environment (i.e. their life environment, their work environment, their educational environment, their cultural activity milieu, their local community, their city, etc.). The consolidated SENSE.STEAM roadmap emphasizes the salience of *social inclusion* and *gender equality* as integral elements of inquiry at this layer of the roadmap.

The 'What' layer: This layer pertains to development of *integrated STEAM subjects*, as well as the *educational and pedagogical model* corresponding to the learning of those STEAM subjects (instruction strategies such as process-based learning) in accordance with the educational level at which the consolidated SENSE.STEAM roadmap is implemented. The essence of STEAM is that teaching of disciplines does not happen in "silos" of independent subjects, but that those lessons or practices are taught in comprehensive, interdisciplinary, inquiry-driven and project-based ways. Accordingly, at this layer, also the clear meaning of STEAM education for the entity (individual or organization) in connection to its role in tackling the wider societal challenges is elaborated. The consolidated SENSE.STEAM roadmap emphasizes the salience of *human sense-experiences* as a central element of STEAM education at this layer of the roadmap.

The 'How' layer: This layer addresses the resources and abilities needed for the development, implementation, and evaluation of the integrated STEAM subject and the related educational models. Accordingly, and depending on the scale of implementation, this layer concerns *STEAM teacher education*, *STEAM transdisciplinary collaboration and training constellations*, *STEAM education support policies* at different levels, as well as *STEAM as a discourse* in the learning environment, education system, and the society. The consolidated SENSE.STEAM

roadmap emphasizes the salience of *space* as an integral element of inquiry at this layer of the roadmap.

Based on this, we envisage the first sketch of the consolidated SENSE.STEAM Roadmap by the following chart, which is intended only as the first draft of the roadmap and is to be further completed during the next phases of the project, as well as getting evaluated by the STEAM Labs (see Figure 1).

It is notable that an additional layer in roadmaps is often added to indicate the concrete action plan (To-Do list) which we did as the part of the roadmap which needs to be decided by each specific entity using the roadmap in accordance with their more specific goals, resources, and capabilities. Such an action plan ideally contains concrete deadlines foreseen for the accomplishment of the planned actions.

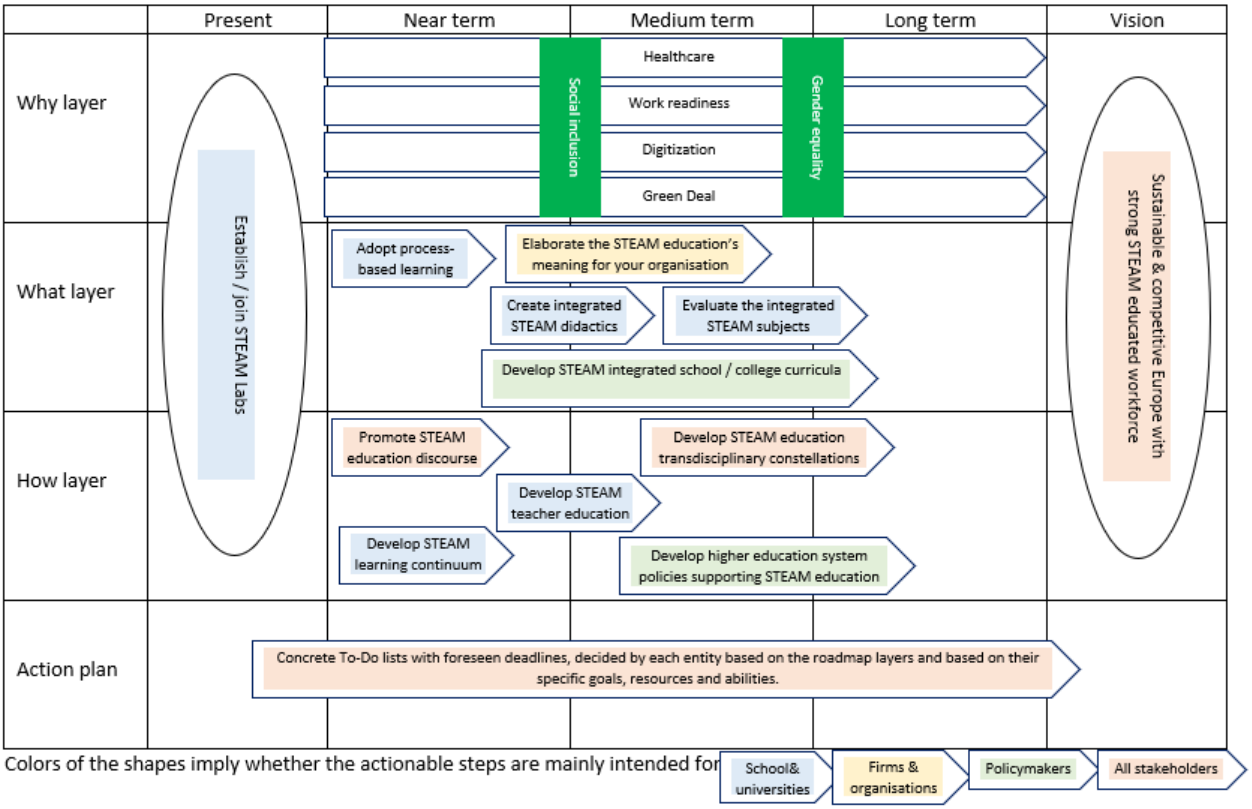

Figure 1: The initial elements of the consolidated SENSE.STEAM Roadmap

3. Conceptualising the materialization of a roadmap

The following section documents the process of how the SENSE. consortium arrived at a first shared vision for the SENSE.STEAM roadmap. The vision was created collaboratively using creative methods during a workshop moderated by partner Velvet, in which all partners elaborated on the key characteristics a roadmap to come. The section goes on to document how using the working methods of designers, the consortium worked first as individuals and then in groups to document, discuss and articulate their values for the roadmap before rapidly producing a physical prototype and reflecting on the results. Finally, common themes are established, linking back to the points of departure set in Section 2 and placing them within the wider project context.

3.1. Background and overall approach to the roadmap visionary workshop

The brief for the workshop was to run a visionary workshop for the SENSE.STEAM roadmap during project meetings of the consortium 2-6 October 2023.

In consultation with the organising team of Work Package four (and the deliverable D4.4 Learning Companion) the workshop was planned on the basis on the metaphor of a roadmap in a literal sense – a resource for guiding a person from their own given (and unique) starting point to their chosen destination.

From this point of departure, the intention was to create a participatory workshop that began with individual reflection, before working in small groups to create a first visualisation of a draft roadmap.

The workshop design was influenced by Velvet's approach as a strategic design agency and the book "Anyone Can Be a Designer" (Moradganjeh, 2017), aligned with the work of the SENSE. consortium and the general assembly topics. The agenda featured a session on the cross-cutting issue of space, a learning companion, and brainstorming, roundtables, and workshops across work packages.

Velvet's design approach consists of the four stages:

1. Building empathy and discovering insights,
2. Validating options, developing opportunities,
3. Designing,
4. Deploying.

These stages have been adapted from the British Design Council's double diamond approach of *discover, define, design, develop and deliver*.

Adapting these approaches to the needs of the project resulted in a six-step workshop as describe in the section below.

3.2. Creating a common vision for a STEAM roadmap

The workshop was moderated by Joseph Sturm, head of digital at Velvet with 17 participants taking part from across the consortium. All participants took part on site and were actively engaged.
Participants were first presented the overall approach (see section 3.1 above) as well as introduced to Moradganjeh's book.

The four stages of a design process were translated into six steps:

i)	building empathy and discovering insights	step 1 and 2
ii)	validating options, developing opportunities	step 3
iii)	designing	step 4 and 5
iv)	deploying.	Step 6

Step 1: Reframing goals or: the Why why why exercise

Participants were asked to think about what the term *roadmap* means and what they want from the roadmap. They were then asked to ask themselves *why* five times. Each subsequent why refers to the answer of the previous one. The intention is to finally reach the underlying reason for the goal they are setting.

Step 2: Talking to people

Participants shared the results of the "Why why why" exercise with one another to broaden ideas and get feedback. They were encouraged to do this a second time with another person, ideally from a different background or discipline.

Step 3: Listing values

Returning to individual work using the guiding sentence "*I/my organisation/my target group values …… So ….. "*participants were encouraged to identify the significance of the goals they had identified to reframe insights and stories as values to design for. This means linking the goals back to something tangible – for example in a digital context rather than saying *I don't mind having to log in every time* is reframed as *I value security more than comfort* and the insight is that in terms of values, something secure needs to be designed (Moradganjeh, 2017).

Step 4: Ideation of values

Participants were asked to self-organise into groups of 4-5 participants each. With a set timer the first task was to brainstorm initial ideas of what the roadmap could be. Speed was encouraged and practical considerations disregarded to encourage creativity.

Step 5: Ideation

The groups were given the task to physically prototype a first version of the roadmap using available materials such as paper, pens and simple art and craft materials. Key inputs were the results of the prior independent and group work as well as the overall context and aims of the SENSE. Project.

Step 6: Reflection

On completion of the task, other participants were asked to give their interpretations of the four roadmaps. The authors of each roadmap then shared their own goals and design intent before a wider group discussion. After completion of the task, personal and group reflections were requested and collected on a voluntary basis. Input was received from 14 of 17 participants. These results are summarised in the following section.

3.3. Outcomes of the workshop

Following a lively and productive exchange of ideas, participants combined their individual insights to create tangible and visually captivating representations of their roadmap designs, exceeding mere conceptualisation. This section presents the findings and ideas gathered from both the personal data collection and the group work that led to the development of tangible models during the workshop.

Roadmap 1: ‘Feris wheel’

Figure 2: Physical Manifestation of Roadmap 1. photo: Joseph Strum

The authors of Roadmap 1 revisited the term *roadmap*, landing on the term *journey map* by the end of their work instead to create a more personalised experience. The group were keen for the roadmap to deploy a network structure, to encourage idiosyncratic encounters, facilitate multiple journeys in order to address the continuum of stakeholders’ motivations to engage with the roadmap, instead of setting pre-determined outcomes.

The team was eager to promote co-creation and collaboration. Upon further examination, a team member noted that the map incorporated the SENSE. manifesto's principles. The manifesto's domains must be assessed to determine how they can function as possible channels for facilitating STEAM stakeholders' usage and implementation of the roadmap.

Roadmap 2: ‘the pyramid’

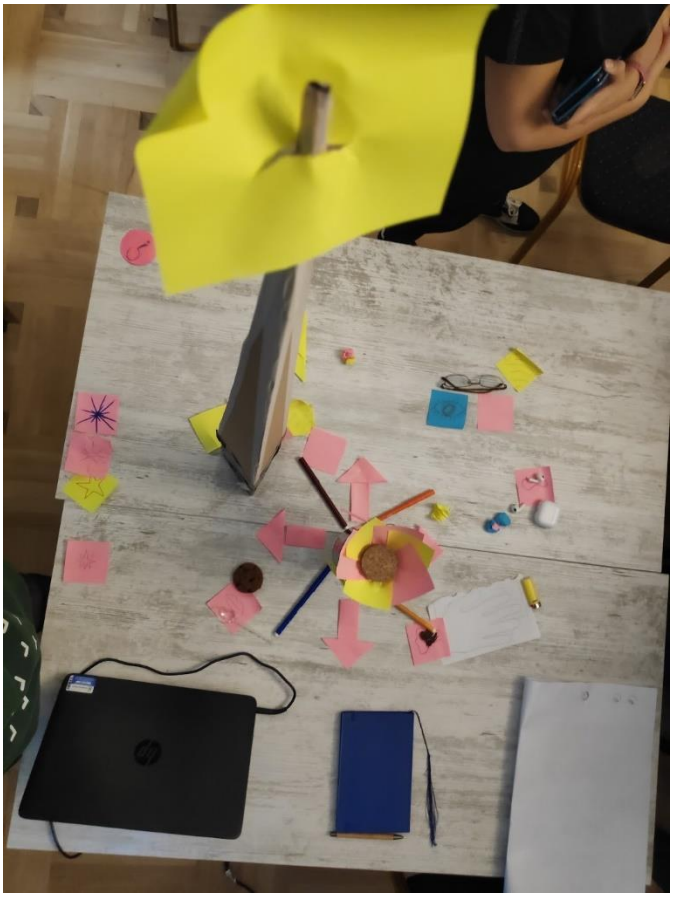

Figure 3: physical manifestation of roadmap 2. Photo: Joseph Sturm

The authors of Roadmap 2 deliberately sought to take a provocative and whimsical approach. The roadmap is centred on a *bucket of elements* within a compass rose. In a playful – and jestful – attempt to encourage uptake and dissemination the bucket cannot be accessed (‘picked up’) without the help of another person.

Drawing on a desire for personalisation and user-centredness the user can reorder and move elements as needed for their own experience. Recognising the pan-European aims of the SENSE. Project no words are used, relying rather on being fully visual to exclude the need for a particular language.

On later reflection a group member noted that despite the provocative and deliberately impractical approach, underlying principles emerged including accessibility and inclusivity, the need for collaboration, agency and bringing out sensory experiences.

Roadmap 3: ‘the SENSE.STEAM musical’

Figure 4: physical manifestation of roadmap 3. Photo: Joseph Sturm

The third roadmap was created as a dynamic and multi-layered scaffold for making things happen. The underpinning concept is a stage for a STEAM musical and TV series. It was important to the authors that the roadmap not lose a sense of fun, provide a range of possibilities and room for evolution. Key to this roadmap is remaining accessible and keeping artistic momentum.

On later reflection a group member brought out a strong desire to encourage free expression and reject the right/wrong dichotomy often seen in schools.

Roadmap 4: ‘the mini metro'

Figure 5: physical manifestation of roadmap 4. Photo: Joseph Sturm

The authors of Roadmap 4 were keen to create means for personalised journeys and learning. The layout is deliberately non-linear and additional ‘cards’ in the categories of *Needs, Risks, Mitigation* and *Limitations* are included which provide help should a user’s journey be disrupted. Personalised journeys are represented by string connecting pins, and further using the metaphor – should the string be too short, going back to learn more, will enhance the experience and reroute the journey.

On later reflection a group member doubled down on the importance of personalisation of journeys.

3.4. Key issues emerging from the four roadmaps

Roadmaps are useful tools for stakeholders, and they can take on two main design structures: network or linear. A linear roadmap follows a clear path from one milestone to the next in a sequential and orderly manner. Conversely, a network structure allows for a more interconnected and flexible approach, enabling multiple pathways and interdependence among various components. The decision on which structure to use relies on the project's nature, organizational goals, and the intricacy in connections with various elements. Every structure has its benefits and drawbacks, allowing organizations to adjust their roadmap design to suit their particular objectives and changing initiatives.

The results of the workshop strongly point to organisational goals (in terms of the SENSE. consortium) preferring the network structure.

When going over the outcomes of group work in the workshops, and open reflection in the period after, a number of common themes emerged:

- Firstly, sensing and experience should take precedence over 'right' or 'wrong' answers and the experiences should be multilayered and meaningful. This means the outcomes of the roadmap should not only be read and understand but engaged with meaningfully.

- Building on the first theme, the importance of personalisation was repeatedly singled out. This is in alignment with Objective 4 of the project including to *introduce a paradigm shift in STEAM education, by stimulating learners' self-directed and co-operative learning.* Allowing users of the roadmap to come in and leave as they please by making non-linear journeys possible adds a further dimension to personalization.

- At the same time as wishing to afford maximum personalisation, encouraging and empowering collaboration – both online and in person – was another common theme. This means it is expected that the roadmap should foster participatory approaches, and in particular enable not only seeking of answers, new approaches and practices, but also giving and sharing of these.

- Finally, there is a strong streak of fun, whimsy and even a little anarchy in the visions developed. Participants leveraged the full extent of their creativity to propose unconventional methods to fully engage diverse stakeholders through multiple senses. For the roadmap to become a serious contender for disseminating and changing existing educational approaches and practices the usefulness of this element should not be underestimated.

Viewed together these common issues can serve as a foundation for continuing with development of the roadmap. They provide a guide for the overall direction of ongoing work and mark the consortium's preliminary vision and point of departure.

Returning to the background established in Section 2.1, and the eight steps identified for achieving he roadmap, the themes of sensing and personalisation will build strong awareness introducing new levels of understanding of STEAM education. A personalised experience creates action through the theme of collaboration. Finally, to reach the final stages of the roadmap through advocacy, combination of creativity, fun and whimsy with collaborative approaches will allow users to the roadmap to have a strong personal connection. Having engaged to make it their own they will gladly advocate for the SENSE.STEAM roadmap.

4. What's next?

After tackling outlines for the SENSE. roadmap, the consortium will intensify their work to better understand how SENSE.STEAM activities can be adapted to the specific needs of our target groups. We will use the knowledge gained from previous project phases and move towards evaluating the practical aspects of the roadmap. The following sections outline key aspects of the plan, such as breaking down theories into actionable steps, creating supportive tools, and collaborating effectively. We also discuss the importance of integrating various educational elements and utilizing technology for support. This guide aims to facilitate the successful execution of STEAM educational initiatives. The guide is not just theoretical, but also adaptable to suit varying groups. Subsequent sections will detail the guide's creation and provide useful tips to assist educators, policymakers, and stakeholders in the dynamic field of STEAM education.

4.1. How the previous and future work in the SENSE. Project will feed into the roadmap

Previous Work Shaping the Roadmap

The foundational blueprint of the SENSE. roadmap is built upon extensive research conducted in Work Package three, enhanced by valuable inputs from Work Packages four, five and six. The culmination of diverse stakeholder knowledge and experiences, including partners, associate partners, organizations, and individuals engaged in STEAM Lab activities, significantly contributes to the genesis of the roadmap. Work Package 4's discoveries are critical in shaping the project's advancement, guaranteeing a reinforced implementation of the roadmap. Moreover, inputs and resources from Work Packages 5 and 6 play a crucial role, converting the roadmap into a comprehensive guide for successful STEAM education. Major components emphasised involve the significance of guidance, self-evaluation, and peer learning approaches.

Future Work and Roadmap Development

Our primary goal is to condense and distribute our findings to establish a *European Roadmap for STEAM education*. This roadmap, a key outcome of our project, will be based on the established SENSE.STEAM methodology advocating for an integrated approach towards STEAM education. The roadmap will emerge in educational and other supportive materials such as a learning companion with a modular format that aims to enable self-guided and collaborative learning. Using digital tools, the learning companion will be a multimedia output that aligns with SENSE.STEAM's pedagogical approach.

The STEAM Academy will integrate the roadmap into the European learning continuum, providing a hybrid platform for STEAM stakeholders to collaborate and communicate. The Academy's digital platform will also facilitate stakeholder engagement and knowledge sharing, acting as both an Academy and Laboratory. The roadmap will undergo two pilot real-world applications to showcase and assess its effectiveness, enabling further customisation to specific contexts.

The success of the project relies on reaching out to STEAM users throughout Europe and ensuring the roadmap's sustained viability beyond the project's lifespan. Achieving this goal necessitates collaborating with other STEAM initiatives, as well as with Erasmus+ and Horizon Europe projects. Furthermore, we are collaborating with other projects that have received funding from the same call. This has resulted in a powerful joint effort to create a robust and versatile tool for STEAM education across Europe.

4.2. Plans for the implementation of the roadmap

The roadmap is flexible and suitable for implementation in diverse educational settings and supporting organisations. Consequently, parties involved in STEAM education can choose pertinent roadmap components based on their requirements and institutional capacities. The roadmap acts as a reference for outlining the integration of the SENSE. approach into STEAM education. Addressing the continuum of awareness, action, and advocacy, we recognize the critical need to enable STEAM by engaging stakeholders from diverse backgrounds and motivations to develop an "action plan" for their individual roadmap towards STEAM. This plan should contain practical steps and necessary resources for achieving their goals. The implementation levels of the roadmap and their respective action plans address essential needs on three distinct structural levels:

- STEAM micro-cosmos: STEAM teachers and STEAM classes

At every level of adopting the SENSE.STEAM approach to education, the initial step is developing an awareness. At the level of individual teachers and classes, which we refer to as the STEAM micro-cosmos, becoming part of STEAM Labs by taking part in their events and training or establishing one is a fast way to familiarize oneself with the SENSE. approach to STEAM education. The main objective of these labs is to enhance the knowledge and skills of both teachers and students in two areas: 1) how to incorporate artistic practices that rely on human senses, multisensory and aesthetic inquiry into science education, and 2) how to enable students to independently develop their skills and abilities by using process-based learning pedagogies in science education. This should lead to the creation of 'integrated STEAM subjects' in schools, where science courses will be revised in the near future. Teachers can tailor these new subjects to the specific context by integrating subjects like physics and art and taking into account available teaching space. The fresh STEAM

topics will be polished gradually through methodologies from educational research, like design-based research (DBR).

- STEAM meso-cosmos: STEAM education networks (multi-entity / interorganizational constellations)

The plan can also be put into action within an educational network or community of practice, where different people take on various roles for STEAM education. We call these groupings STEAM meso-cosmos. Different stakeholders would have different action plans, but they should coordinate for the best results. So, once all parties involved have been identified, the next step is to create or choose a coordinating group. After this, a unified set of schedules should be established for each participant in their particular role (e.g. education, work experience assistance, curriculum creation, and so on).

- STEAM macro-cosmos: education systems (national / transnational / European education and research area)

At the highest level, the combined plan could act as a reference for enhancing STEAM education throughout national education and higher education systems, as well as in the European education and research region. We refer to this level as the STEAM macrocosm. The widespread rollout of the roadmap means that the way science is taught in primary, secondary, and tertiary education needs to be redefined according to the ontological and epistemological principles of the STEAM and SENSE.STEAM approaches. Education policies and strategies must acknowledge the importance of a combined approach to science education, which is the basis of the science education infrastructure. Thus, it is necessary to improve and promote the discourse around STEAM education by key individuals and organizations such as lawmakers, government departments, universities, and schools.

5. Conclusions

In conclusion, creating a STEAM education roadmap is a crucial move towards enhancing STEAM education and innovation in Europe. This report has outlined the key elements we distilled to be involved in designing the roadmap, starting with an analysis of the context, and meaning of roadmap in STEAM education. By conceptualising the process of materialisation, we participated in a visionary workshop that not only presented a well-structured approach but also produced noteworthy and enlightening results.

The workshop's outcomes, highlighted in Section 3.2, form the basis for comprehending the significant challenges emanating from the four roadmaps, as discussed in Section 3.3. These challenges, spanning from curriculum design to teacher training, highlight the multifaceted nature of STEAM education and accentuate the necessity for a strategic roadmap to tackle these complexities.

Turning our attention to the future, Section 4.1 points out the crucial part played by the SENSE. Project in shaping the roadmap. The harmonious interplay between the project's past and forthcoming work guarantees a steady stream of knowledge, resources, and expertise, bolstering the roadmap's resilience and flexibility. Section 4.2 details strategies to implement the roadmap, demonstrating a resolve to convert theoretical concepts into practical steps that will have a favourable effect on STEAM education throughout Europe.

Essentially, creating a STEAM education roadmap is not just a mental exercise, but a driver for substantive transformation. It is an adaptable instrument that enables educators, policymakers, and stakeholders to manoeuvre the evolving education landscape, equipping upcoming generations with the competencies and information essential for thriving in a swiftly changing world.

6. References

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