Surrounded by Science

Learning Paths towards Science Proficiency

Research and Innovation Action in the European Union's Horizon 2020 Programme

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Deliverable 2.3

Inventory of Activities

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Executive Summary

This document presents the inventory of iSTEM learning activities and studies selected for further research. The goal of this deliverable is not only to introduce the inventory and the study selection but also to show how the process of collecting data and selecting cases was organised.

Creating the inventory was done in parallel with working on D2.2 *Surrounded by Science Key Characteristics and Matrices*, and was informed by the other deliverable. More than 50 activity providers from nine countries inside and outside the consortium were interviewed to get information about the activities they organise, and these interviews were used as the main source of data for creating the inventory. Project partners' network and expertise in organising activities were also used to contribute to the inventory construction. The presented inventory includes 76 activities from all three learning contexts: 35 outreach programmes, 20 designed environments, and 21 technology and media products. These activities vary by their type, country of organising, target group, target STEM areas, and intended time.

From the inventory, 18 case studies, six per context, were selected for further research. Several content-related selection criteria, such as context, activity type, STEM areas, activity provider, and country were used to ensure the selection to include a variety of well-designed activities. Practical considerations, such as an activity meeting most success criteria and a possibility to collect data were applied to make the data-collection process both informative and feasible. The selected case studies will be used in the second phase of the project – the Research phase.

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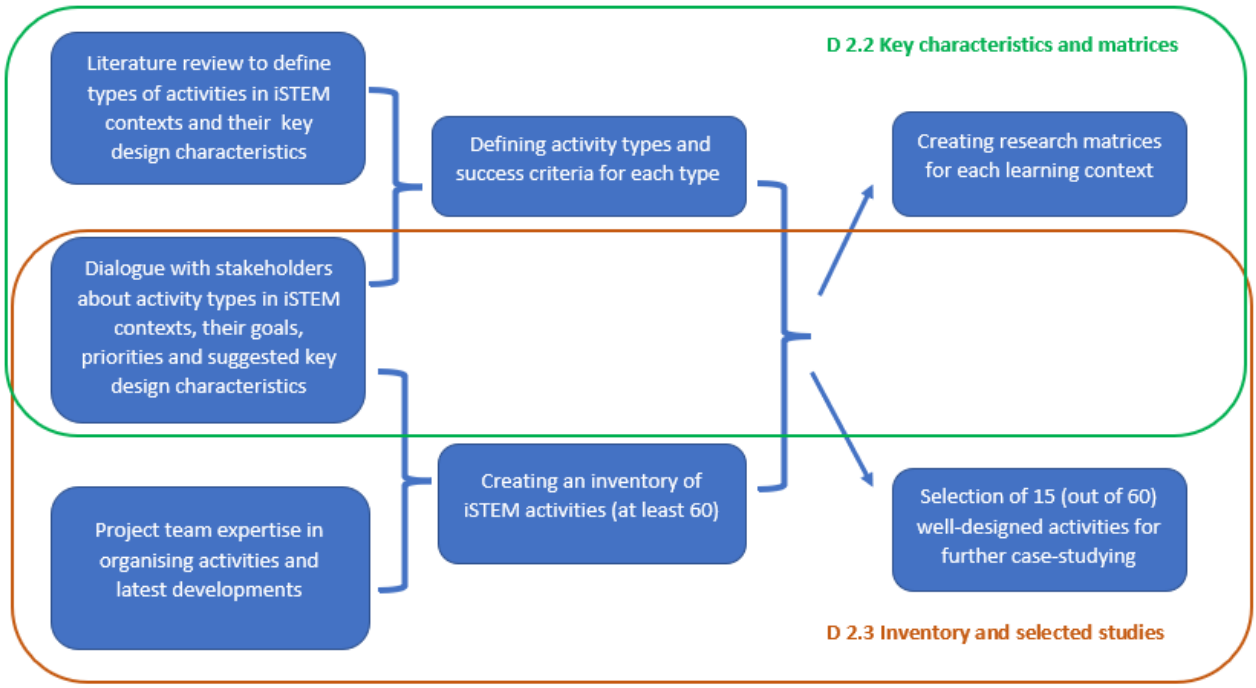
1 Introduction

This document presents the creation of an inventory of existing iSTEM learning activities that have the potential to support the development of science proficiency in their target audience. The goal is to get an overview of available types of activities in science education occurring outside the classroom. It will, however, not only serve as a snapshot of existing iSTEM activities in Europe and beyond, but it also provides additional insight into the approaches that science organisations are taking to engage with visitors, spark their interest, and stimulate learning. From the inventory, activities for case studies are selected, a process that is also described in this document, as well as the resulting list of selected case studies.

The tasks described in this deliverable are intertwined with the tasks described in deliverable D2.2 *Surrounded by Science Key Characteristics and Matrices.* Both deliverables were based on parts of the same data collection, namely interviews with activity providers. Figure 1 shows a diagram of this intertwined process.

Moreover, as this document lists the studies selected for research and assessment, it is not only one of the final deliverables of WP2, but it also lays out the road for the next phase of the project – the research phase. This means that it provides input for the work of several work packages – Research implementation (WP4), Impact assessment (WP5), and Digital toolbox (WP3).

Figure 1. *Connection between different tasks and deliverables within WP2*



After this introduction, Chapter 2 starts with the description of how the information about iSTEM learning activities for the inventory was collected and how it is presented in the inventory.

Then the categories of information that are important to include in the inventory to facilitate the process of selecting case studies are described. The chapter ends with the inventory, in which example activities from three learning contexts (outreach programmes, designed environments, and technology and media products) are described.

In Chapter 3, the selection criteria for the case studies are described, after which the selected case studies are presented.

Chapter 4 gives a summary of the document and connections to the work of other work packages are presented.

2 Inventory

This chapter presents the inventory of existing science activities that have the potential to support the development of science proficiency in their target audiences. Before the inventory is presented, the approach that was followed to collect information will be described. Moreover, the categories of information, that are used to report on the activities in the inventory, will be described and justified.

2.1 Approaches to collect the information

The aim of the inventory is to give a snapshot of existing iSTEM learning activities and to provide insight into the approaches that organisations are taking to engage with visitors, spark their interest, and stimulate learning.

The main source was talking to activity providers. The task of collecting examples of existing iSTEM learning activities went hand-by-hand with the Scanning the horizon task (see D2.2), and for that task activity providers were approached. The project team used their network to contact activity providers because each activity in the inventory was treated as a potential case study and it was important to have access to more information about it. Announcements and information about iSTEM learning activities taking place during the work on this task (February-June 2022) in the countries of the consortium members were also used as a source of inspiration of which activity providers to approach in a specific country.

Fifty-one activity providers from nine countries were interviewed: five of the consortium countries (Italy, Portugal, Israel. The Netherlands, and Greece), and four countries outside the consortium (Finland, Sweden, Germany, and the USA). The data of these interviews were used for different project tasks, including creating the inventory. More information about the interviews and the questions can be found in D2.2 *Surrounded by Science Key Characteristics and Matrices*. During the interviews, activity providers were asked to describe several example activities that they organise. These activities were later included in the inventory. It is important to mention that activity providers chose which activities to talk about themselves. When asked about the reasons behind this choice, they mentioned that these activities were popular and/or successful ones. This means that we include activities that are viewed as successful by activity providers and are popular among the visitors/participants.

Project-member organisations were encouraged to include some of the activities that they provide to the public. This not only allowed to present the expertise of the project team but also covered activities with easier research possibilities.

2.2 Categories in the inventory

This section gives an overview of the information that is used to present each activity in the inventory together with the explanation why these pieces of information are important to include. This is shown in Table 1.

Table 1. *Categories of the inventory*

Category	Description and rationale
Activity provider	Indicates which organisation provides the activity. It gives information about what type of organisation it is (e.g., a museum, a university) and it allows us to reach the organisation for further collaboration.
Country	Indicates in which country the activity takes place, which gives an overview of countries represented in the repository. This is also important for selecting case studies to ensure data collection in different countries.

Context	Indicates which of three learning contexts the activity belongs to: outreach programmes, designed environments, or technology and media products. Knowing this allows to ensure that all contexts are presented in the inventory. This also helps in selecting case studies to provide equal distribution across contexts.
Activity type	Indicates to which activity type this activity belongs (see D2.2 for more information about activity types). This shows the diversity of activity types in each learning context and helps in selecting case studies of different types.
STEM area(s)	Indicates to which STEM area or areas this activity contributes to, which allows to ensure a representation of different STEM areas in the inventory. The area is also taken into consideration in the process of selecting case studies.
Contribution to the SP strands	Ranks the strands of science proficiency (SP) in order in which this activity contributes to their development (see D2.1 for more information about science proficiency strands). This gives an overview of more and less contributed science proficiency strands and also helps in selecting case studies.
Description	Indicates what actions participants are supposed to take during the activity, which helps to get a view of what the activity entails.
Target group	Indicates what group or groups of population this activity targets. This helps to ensure a representation of activities for different target groups in the inventory and in the selected case studies.
Intended time	Indicates time planned for the activity by the activity provider, which provides an overview of different activity duration. This also helps in selecting case studies to ensure a representation of activities of different duration.

SP – Science proficiency

For the category *Activity type*, the activity types that were identified in D2.2, were used. Activity types for each learning context are given in Table 2. More information about the activity types can be found in D2.2.

Table 2. *Activity types per learning context used in the inventory*

Outreach programmes	**Designed environments**	**Technology/media products**
1. summer or afterschool science camp or club	1. guided tour	1. website with various activities (tutorials, MOOCs, reading materials)
2. a lecture or a series of lectures with some interactive activities (e.g., debates, tours, demonstrations, experiments)	2. unguided visit to an exhibition with exhibits of various levels of interactivity	2. any printed offline products (comic books, leaflets on science content, etc.)
3. science and technology projects	3. designed route with tasks (unsupervised)	3. radio and tv programmes, podcasts, channels in social media
4. workshop or a series of workshops		4. online exhibition
5. scenario-based activity (e.g., escape room, treasure hunt)		5. digital scenario-based activity
		6. dissemination events

For the category *STEM areas*, different levels of specificity were used. The STEM areas include Science, Technology, Engineering and Math, and are presented at the level that was mentioned by the activity providers, which means that they can either be general (e.g., science) or more specific (e.g., physics, neuroscience).

For the category *Contribution to the SP strands*, the strands of science proficiency (SP) as described in D2.1 are used. Table 3 shows the strands that constitute science proficiency and the

labels that are used in the inventory. More information about the strands of science proficiency can be found in D2.1.

Table 3. *Science proficiency strands and the labels used in the inventory*

Strand of science proficiency	**Label in the inventory**
Understanding scientific content and knowledge	understanding
Engaging in scientific reasoning	reasoning
Reflecting on science	reflecting
Being interested in and excited by science	interest
Using the tools and language of science	using
Identifying with the scientific enterprise	identifying

In the same column, the numbers indicate to what extent this activity contributes to the development of each strand according to the activity provider. The following categories are used:

- 1 – no contribution,
- 2 – to a very small degree,
- 3 – to a moderate degree,
- 4 – to a good degree,
- 5 – to a very large degree.

For the category *Target groups*, target groups are indicated by educational levels (e.g., upper primary school children, lower secondary school pupils) or by type of audience (e.g., schoolchildren, families, general public).

2.3 Inventory of activities

This section presents the inventory consisting of 76 iSTEM learning activities. These activities come from all three learning contexts: outreach programmes (*n* = 35), designed environments (*n* = 20), and technology and media products (*n* = 21) and satisfies the target of 20 activities per learning context, as promised in the proposal. The larger number of outreach programmes (compared to the other two learning contexts) is caused by the fact that, during the interviews, most museums, science centres, and other designed-environment institutions chose to speak about their outreach programmes, such as specially organised activities, like workshops and lectures instead of their regular exhibitions.

According to the proposal, at least six of the activities in the inventory should focus on the involvement of participants from rural and remote areas, which is fully fulfilled by the presented version. Most of technology and media products can be followed online, which makes them suitable for users in various places, including the rural and remote ones. For example, a virtual visit to a Galileo museum in Italy (#3 in the inventory) can be done by users in any place in the world, and a digital chemistry escape room (#45 in the inventory) allows students from different parts of the country to solve chemistry problems. Several of the described designed environments are located not in the big cities but in rural areas, for example, Natura Docet (#18 in the inventory) and Nordhorn zoo (#46 in the inventory) and are easily accessible for local visitors. Finally, several outreach programmes target participants from rural areas as well as from cities, for example, Maker lab (#33 in the inventory) and Project 19 (#54 in the inventory).

Table 4 presents the inventory in alphabetical order of activity names. Some cells are empty as, due to various reasons, sometimes the required information was not obtained. A digital version of the inventory is available through the following link: https://surroundedby.science/midReview/deliverables/D2.3_Inventory.xlsx. In this version, the activities can be ordered by any category.

Table 4. *Inventory of iSTEM activities*

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
1	90 seconds of science	Antena 1-Novartis - ITQNOVA	Portugal	Technology and media products	media product: podcast	all STEM areas	understanding -5; reasoning -5; reflecting -3; interest -3; using -1; identifying -1.	This is an activity that aims at attracting people's attention to science and scientific discoveries, a kind of a science appetiser.	general public	90 seconds per episode
2	A stem cell adventure	University of Coimbra	Portugal	Technology and media products	offline product: comic book	neuroscience general health	understanding -3; reasoning -2; reflecting -3; interest -5; using -3; identifying -4.	The person reads, reflects and is excited to see other work in the area, the reader is invited to make their own comic (or cartoon strip).	upper secondary school pupils and university students	0,5 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
3	A virtual visit to Galileo museum	Galileo museum	Italy	Technology and media products	online exhibition	all areas of STEM	understanding -3; reasoning -2; reflecting -2; interest -5; using -3; identifying -1.	The virtual visitor to the Galileo Museum in Florence explores the discoveries and the archives of Galileo Galilei through different access modes. The visitor can personalise their experience, e.g., by repeating the experiments of Galileo through innovative tools that are available today.	secondary school pupils	1 h
4	Alla scoperta delle pietre storiche da costruzione (Discovering the historical building stones)	Centro Musei delle Scienze Naturali e Fisiche	Italy	Outreach programmes	lecture with interactive activities	geology, earth science, biology, chemistry, engineering, architecture	understanding -5; reasoning -5; reflecting -4; interest -5; using -4; identifying -3.	The programme shows how the geology of the cities of art influences their architecture. First, participants attend the seminar to learn about building stones and materials in general, and then they go around the city to watch what they have learned.	students of all types of school, general public	3 h
5	Apenheul visit	Apenheul	The Netherlands	Designed environments	unguided visit	biology, ecology	understanding -4; reasoning -3; reflecting -4; interest -5; using -3; identifying -2.	Park with over 300 apes, which are free roaming. Visitors walk around and observe the apes. Information is provided at stands and at the interactive part.	families with children from 2 y.o	a day trip
6	Astroni wood to know and defend	Oasi Naturalistica degli Astroni	Italy	Outreach programmes	lecture with interactive activities	natural science, biology	understanding -4; reasoning -3; reflecting -3; interest -4; using -3; identifying -2.	A programme is created to explain to children the wealth of the place and its biodiversity. So they listen to explanations, answer questions and play games (like ThingLink and Learningapps).	primary and secondary school children (6-13 y.o.)	4 h (4 meetings; 1 hour each)
7	Bacteria identification	Vetenskapens Hus (the House of Science)	Sweden	Outreach programmes	workshop	biology, technology	understanding -4; reasoning -2; reflecting -2; interest -4; using -4; identifying -2.	Students get an introduction about different bacteria types and then work on groups to identify and analyse a given sample.	upper secondary school pupils	3 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
8	Birdwatching 2.0	Oasi Naturalistica degli Astroni	Italy	Outreach programmes	science project	science, biology, technology, ethology	understanding -4; reasoning -4; reflecting -4; interest -4; using -2; identifying -2.	Some special burrows and nests were built with a very small wireless webcam that let to observe what happens inside without disturbing their inhabitants So children watch the video recorded by the webcams and then use the didactic material to complete some cards and answer the questionnaire about the animals after the experience. . The goal is problem solving because children are involved in the design of the burrows and nests even though they were already created.	primary school children (7-10 y.o.)	10 h (10 meetings; 1 hour each)
9	Black Hole Hunter	Cardiff University Gravitational Physics Group	UK	Technology and media products	website: online game	physics		Users are engaged in online play-based activities which spark their interest, excitement and motivation to learn about phenomena in the natural and physical world. In this game, users listen to gravitational wave detector data and determine whether or not they can hear the given gravitational wave signal in the sound file, or whether it is just noise.	secondary school pupils	1 h
10	Bot voor bot (Bone by bone)	De Museum fabriek	The Netherlands	Outreach programme	workshop	biology, environment	understanding -5; reasoning -5; reflecting -1; interest -3; using -2; identifying -2.	Participants work in groups: first they study one skeleton in the exhibition and present the main characteristics to others, then they draw a human arm and study it at the model and their body, finally they compare it with a limb of a mammal and conclude that they are similar.	primary school children (10-12 y.o.)	1,5 h
11	Chemistry Competitions	Weizmann Institute of Science	Israel	Outreach programmes	science project	chemistry	all strands -5	Students first need to choose how many will be in the group and what competition category (out of 7) and topic interests them. They watch tutorial movies about the different competition categories, and what is	upper secondary school pupils	2-3 months with weekly input of 3-4h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
								needed for each product. Then they work on their project and submit it.		
12	Chemistry escape room	Weizmann Institute of Science	Israel	Outreach programmes	scenario-based activity	chemistry	understanding -4; reasoning -- 4; reflecting -1; using -4; identifying -2; interest -5	Participants go into a physical room with chemistry challenges, based on a common theme. Working in groups, they must solve the problems before a pre-determined time period.	upper secondary school pupils	1,5-3 h
13	Corporea	Fondazione IDIS-Città della Scienza	Italy	Designed environments	unguided visit	life sciences; human body and health	understanding -4; reasoning -3; reflecting -3; interest -4; using -2; identifying -2.	An entire museum is dedicated to the human body and its functions. We would like that people become curious noticing phenomena that happens only if they do something interacting with the exhibit. It also talks about health: we want to show to the visitors that paying attention to a system has consequences to all the others. So this is an exhibition with interactive stands, videos, informational panels, etc. Visitors can also attend interactive labs.	general public	1,5-2 h
14	Dark Skies Rangers	Nuclio Nucleo Interactivo de Astronomia Associacao	Portugal	Outreach programmes	science project	physics, astronomy, mathematics	understanding -4; reasoning -5; reflecting -5; interest -5; using -4; identifying -5.	The international programme Dark Skies Rangers, coordinated in Portugal by NUCLIO, aims to fight the problem of light pollution, by raising awareness among the educational community and local authorities to change the lighting systems in order to preserve the night sky. Participants collect data about light pollution in their area and work out solutions to decrease it.	families, schools, general public	1 week
15	Davidson Institute's website	Davidson Institute, Weizmann Institute of Science	Israel	Technology and media products	website	all STEM areas	understanding -4; reasoning -2; reflecting -3; interest -5; using -2; identifying -2.	Visitors can browse at the website and choose activities covering different STEM domain. Among such activities there are quizzes, interesting facts about science or	schoolchildren of all ages, general public	n/a

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
								scientists, experiments to do at home, etc.		
16	De Vlinder-fabriek (The Butterfly factory)	De Museum fabriek	The Netherlands	Designed environments	unguided visit	biology, environmental studies		Visitors learn about the development of butterflies from cocoon to a butterfly, about different types of butterflies and their role in nature. Visitors see models of a butterfly's body to see how they function, collection of butterflies from different regions and are explained how butterflies are presented in a food chain.	families	1,5-2 h
17	Digital chemistry escape rooms	Weizmann Institute of Science	Israel	Technology and media products	digital scenario-based activity	chemistry	understanding -5; reasoning -3; reflection -3; interest -5; using -5; identifying -3.	Students solve different chemistry problems to get out of a digital escape room. Students participate as part of their lesson, so the teachers connect what happens in the chemistry escape rooms to what the students learn in their classrooms. In a digital version, students can also “work” with dangerous substances that is not possible in a real lab. It was especially useful during the pandemic times.	upper secondary school pupils	1-1,5h
18	Dinosaurs route	Natura Docet	The Netherlands	Designed environments	designed route with tasks (unsupervised)	biology, ecology	understanding -3; reasoning -3; reflecting -3; interest -5; using -2; identifying -3.	Participants can observe exhibits like fossils, eggs, bone fragments, etc. covering different dinosaur types. They can follow a route through the rooms: in each room they can find a specially marked board with a small task, a question or an extra piece of information. They can decide to complete it or ignore and move further.	families with children from 6 y.o, general public	1 h
19	Ensico computer workshops	Ensico	Portugal	Outreach programmes	series of workshops	technology, computing, digital literacy	all strands - 5	ENSICO advocates the teaching of computing to all students in primary and secondary education by proposing a programme and	primary and secondary	2,5 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
								curriculum goals that promote digital literacy and ethics based on the domain of Computer Science. Participants are introduced to the basic of coding and can practice these skills immediately.	school children	
20	ESO press conferences	ESO (European Southern Observatory)	Germany	Technology and media products	Dissemination events	all STEM areas	understanding -3; reasoning -4; reflecting -4; interest -5; using -2; identifying -5.	During these events, a 30 minutes presentation is followed by Q&A from media officers and 1h Q&A from public (a scientist is available to answer all questions and engage with the public).	general public	1,5 h
21	Estrazione del DNA (DNA extraction)	Fondazione IDIS-Città della Scienza	Italy	Outreach programmes	scenario-based activity	biology, mathematics, chemistry, genetics	understanding -4; reasoning -3; reflecting -2; interest -4; using -4; identifying -2.	The goal of the activity is understanding the structure of DNA and its discovery but also reflecting on the developments of current research. Students have to find a murderer choosing between 3 suspects.	upper secondary school pupils	2 h
22	Experimenta visit	Experimenta	Germany	Designed environments	unguided visit	physics, technology, engineering, biology, astronomy	understanding -3; reasoning -3; reflecting -4; interest -5; using -4; identifying -3.	Centre with themed exhibitions and more than 275 interactive stations around different subjects from the natural sciences and technology. Visitors can choose their own path.	families with children from 2 y.o., general public	a day trip
23	Explore Evolution	University of Nebraska State Museum, Lincoln	USA	Designed environments	unguided visit	evolution, palaeontology anthropology, biomedical research	understanding -5; reasoning -4; reflecting: -3; interest -5; using -4; identifying -3.	Visitors interact with the exhibits and engage in its various activities, performing experiments, answering questions based on the information shown, etc.	anyone above 12 y.o.	1-1,5 h
24	Explore Nature	Natural History Museum, Tel Aviv University	Israel	Designed environments	designed route with tasks (unsupervised)	integrative biology, i.e., evolution, ecology and behaviour		The route includes five stations. Three of them are exhibits with specimens from the collection. The fourth station is the paper animal station, where the visitors create	general public	45-60 min

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
								animals based on questions. The fifth station has a microscope with a large screen. The visitors can magnify feathers, seeds, and other natural objects and explore them.		
25	Fibonacci's sequence	MathGurl	Portugal	Technology and media products	media product	math	understanding -4; reasoning -2; reflecting -2; interest -5; using -1; identifying -2.	The activity introduces this mathematical phenomenon and points in the directions of research of this subject.	general public	7 minutes
26	Fisica in fabula (Physics in tales)	Ponys	Italy	Outreach programmes	lecture with interactive activities	physics, chemistry, biology	understanding -3; reasoning -4; reflecting -3; interest -5; using -3; identifying -2.	A narrator reads children a very famous tale and brings out a scientific content from it (e.g. thanks to the invisibility cloak from Harry Potter, we can talk about the light and its properties). After the story there are a series of experiments to show the properties that were talked about.	Children 3-13 y.o.	0,5 h per story
27	Get rid of waste	OMA	Portugal	Outreach programmes	workshop	biology	understanding -3; reasoning -3; reflecting -3; interest -5; using -5; identifying -5.	Different hands-on activities are organised with the aim of making children aware of the situation with the wastes in the sea and the ways they can improve the situation.	primary and secondary school children	2-3 h
28	Il consumatore ecologico (The eco-friendly customer)	Associazione di Ricerca e Divulgazione per l'Educazione Ambientale (ARDEA)	Italy	Outreach programmes	series of workshops	ecology, geography	understanding -3; reasoning -3; reflecting -3; interest -3; using -3; identifying -3.	An activity to think about the consequences of our choices in terms of pollution and understand if they are sustainable or not. From the knowledge of the energy used to produce things, to a simulation of a supermarket to know what are the differences between similar products.	general public	3 meetings of 2 h
29	Il popolo della spiaggia (The	Associazione di Ricerca e Divulgazione	Italy	Outreach programmes	science project	biology, zoology, botany,	understanding -3; reasoning -4; reflecting -3; interest -4;	A programme of different meetings in which children start as learners and become first researchers, analysing the beach and all its inhabitants, and	primary school children	30 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
	community of the beach)	per l'Educazione Ambientale (ARDEA)				geology, ecology	using -3; identifying -4.	then "politicians" writing rules for a correct use of beaches. Students listen to the explanation about habitat and species and monitor their activities. They also clean the beaches to analyse what they found and write a "Beach Community Constitution".		
30	Laboratorio di simulazione delle eruzioni (Eruptions simulation laboratory)	Istituto Nazionale di Geofisica e Vulcanologia - INGV	Italy	Outreach programmes	lecture with interactive activities	Earth science, physics, chemistry	understanding -3; reasoning -4; reflecting -2; interest -4; using -4; identifying -3.	This activity demonstrates how a volcano erupts, showing the difference between an effusive eruption and an explosive one. Children listen to a brief explanation and observe the demonstration, sometimes they can also be involved in the demonstration.	primary and secondary school children	0,5 h
31	Laboratorio sugli insetti (Insects laboratory)	Scienza Semplice	Italy	Outreach programmes	lecture with interactive activities	natural science	understanding -3; reasoning -3; reflecting -4; interest -5; using -3; identifying -1.	This activity introduces the insects' world, specifically arthropods. First, some explanations about insects are given and then participants can use all the five senses to know and understand them. All the animals are alive.	general public	1-2 h
32	Leonardo's Questions	Bloomfeld Science Museum, Jerusalem	Israel	Designed environments	unguided visit	all disciplines of science, math, technology, design/ engineering	understanding -4; reasoning -2; reflecting -4; interest -4; using -2; identifying – 4.	The interactive exhibits relate to various mechanism that visitors can manipulate, e.g., the Crain, Archimedes' screw, surfaces with different materials at different angles (for experiments on falling/sliding objects). Also included are some videos on birds and a computerized timeline of Leonardo's life.	general public and school visits	1 h
33	Maker lab	Tetem	The Netherlands	Outreach programmes	workshop	technology+ other STEM areas, integrated		Families (up to 5 people) choose a topic, get a small introduction about it and the technology behind it and then produce something (e.g., recycle plastic to create something new, make a model with 3D printer)	families with children above 6 y.o.	2 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
34	Maker science program	Davidson Institute, Weizmann Institute of Science	Israel	Outreach programmes	series of workshops	all disciplines of science, math, technology, design/ engineering	understanding -3; reasoning: -4; reflecting: -3; interest: -5; using -2; identifying -4	Participants engage in a variety of different activities that combine science and technology. For example, they grow crystals, so they design technological aids to grow and present crystals. In each activity, learners are involved in self-defined projects. The topics are all tied into present-day science and developing products with technological tools.	lower secondary school pupils	30 meetings of 4 h
35	Maker space	Nuclio Nucleo Interactivo de Astronomia Associacao	Portugal	Outreach programmes	workshop	all areas of STEM	understanding -4; reasoning -5; reflecting -3; Interested ?; using -5; identifying ?	Participants take part in workshops, with topics such as 3D printing, electronics and programming, measuring indicators through sensors, building smart home applications like intelligent self-sufficient gardens, pod-casting, video edition, graphics design, working with basic digital tools such as word processor, presentation creation, etc.	anyone above 6 y.o.	4-6 h
36	Master class	University of Twente	The Netherlands	Outreach programmes	series of workshops	physics, chemistry, biology, technology and engineering	understanding -5; reasoning -5; reflecting -4; interest -5; using -4; identifying -4.	A series of three sessions (three weeks): intro, experiments, developing something themselves.	upper primary school children (11-12 y.o.)	3 meetings of 2 h
37	MAV Digital Labs	Museo Archeologico Virtuale - MAV	Italy	Technology and media products	series of workshops	informatics	understanding -3; reasoning -3; reflecting -2; interest -4; using -4; identifying -3.	There are two activities that introduce students to the technology world teaching them the basics about coding and virtual environments creation. Children apply the knowledge directly to solve a problem or create a model.	primary and secondary school children	5 meetings of 1 h
38	MOOC in Recreational Math	Davidson Institute, Weizmann	Israel	Technology and media products	website	math	understanding -3; reasoning -3; reflecting -3; interest -5;	The participants in these MOOCs (there are three) learn math. They engage in the recreational side of math, i.e., the mathematics of bar	general public	each course is 12 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
		Institute of Science					using -4; identifying -3	codes, puzzles, codes, roman numerals, Egyptian hieroglyphics.		
39	Morning Science Program	Givat Olga Science Center	Israel	Outreach programmes	series of workshops	general science (primary schools); science & technology (secondary schools) and physics, chemistry and biology (upper secondary schools)	understanding -4; reasoning -3; reflecting -3; interest -5; using -4; identifying -4.	Participants engage in hands-on activities, with something to take home (e.g., model of particulate nature of matter from clay, electric car, ice-cream via liquid nitrogen). After a small introduction, they first watch demonstrations and then work themselves.	School-children of all ages	
40	Motus: The prehistory of automobile	Galileo museum	Italy	Designed environments	unguided visit	engineering, technology, physics		The exhibition presents ideas that together led to the development of a car. Visitors can see the progress of engineer ideas from the first wheel to the first car. Explanations and some working models are available for the public.	general public	1-1,5 h
41	Moving around Mars	Davidson Institute, Weizmann Institute of Science	Israel	Designed environments	unguided visit	physics, astronomy, engineering, biology, chemistry	understanding -3; reasoning -4; reflecting -4; interest -4; using -4; identifying -4.	Participants interact with many interactive games. For example: What would I take to Mars? How could I breathe? How could I grow plants? There is a game on choosing a house on Mars, given all the environmental conditions (wind, temperature, atmosphere).	general public, especially families with children	1-1,5 h
42	Museo del Reale Osservatorio Vesuviano (Museum of the Vesuvian	Istituto Nazionale di Geofisica e Vulcanologia - INGV	Italy	Designed environments	unguided visit	geology, earth science, physics, chemistry	understanding -3; reasoning -4; reflecting -4; interest -3; using -3; identifying -2.	It is the historical headquarter of the oldest volcanological observatory in the world. It hosts an exhibition focused on geophysics where visitors can learn about the history of Neapolitan volcanoes, observe samples of local rocks and minerals, and a huge collection of old devices	anyone above 12 y.o.	1,5 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
	Royal Observatory)							for volcanological monitoring, as well as enjoy the view from a terrace just above the lava flow produced during the last eruption in 1944.		
43	Mysteriet I Østmarka (The mystery in the forest of Østmarka)	Vitenparken	Norway	Technology and media products	website (online game)	biology, ecology	understanding -4; reasoning -3; reflecting -2; interest -5; using -3; identifying -4.	The activity teaches students about predators and their role in the food chain, so the misconceptions can be treated and a bigger ecological picture can be created.	secondary school pupils (10-14 y.o.)	0,5 h
44	NEMO museum visit	NEMO museum	The Netherlands	Designed environments	unguided visit	physics, technology and engineering	understanding -2; reasoning -4; reflecting -2; interest -5; using -3; identifying -3.	Participants can follow a floor exhibition (that focuses on a theme, like human body or electricity) or visit all floors.	families with children from 8 y.o.	at least 1-2 h
45	NEMO website	NEMO museum	The Netherlands	Technology and media products	website	physics, technology and engineering	understanding -3; reasoning -3; reflecting -2; interest -5; tools -4; identifying - 3;	People can look for a specific topic (electricity) and get all the activities about it, or they can browse and choose different things (facts, quizzes, experiments), or they can be suggested something based on the weather, day, season etc.	families and children above 7 y.o.	n/a
46	Nordhorn zoo tour	Tierpark Nordhorn	Germany	Designed environments	guided tour	biology, ecology	understanding -4; reasoning -3; reflecting -4; interest -5; using -3; identifying -2.	A class is given a guided tour at the zoo: they see live animals, listen to a zoo teacher and see/touch elements like fur, bones, etc. There can be a small educational game in the middle when they need to complete a task in teams.	primary school children (6-12 y.o.)	1-2 h
47	Nordhorn zoo visit	Tierpark Nordhorn	Germany	Designed environments	unguided visit	biology, ecology		Visitors see different animals and read informational boards about them. There is a pet zoo, where small children can touch and pet animals.	general public	1,5-2 h
48	Observation nights	Ellinogermaniki Agogi Scholi	Greece	Outreach programmes	workshop	astronomy	understanding -3; reasoning -2; reflecting -1;	Participants conduct observations of Jupiter and Saturn by using a modern telescope and compare their	general public	2 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
		Panagea Savva AE					interest -5; using -4; identifying -1.	observations with the ones made by Galileo.		
49	Oyfo Techniek-museum visit	Oyfo Techniekmuseum	The Netherlands	Designed environments	unguided visit	physics, technology, engineering	understanding -3; reasoning -3; reflecting -4; interest -5; using -4; identifying -3.	Centre with exhibitions about different themes within science and technology. Students can explore, interact and experiment.	families with children from 6 y.o	2-3 h
50	Passione virale (Viral Passion)	Fondazione IDIS-Città della Scienza	Italy	Technology and media products	online exhibition	biology, epidemiology, engineering	understanding -4; reasoning -4; reflecting -4; interest -4; using -4; identifying -4.	This is a virtual exhibition about viruses in general and Covid-19. We tried to create something which was as real as possible so the people who couldn't go out during the lockdown didn't have to give up the idea of visiting a museum and learning something. Public can visit the rooms with a 360° vision, read information on viruses, watch pictures, and interact with 3D models.	general public	n/a
51	PBLSAT (Project-Based Learning in Science and Technology)	Katzir High School and Weizmann Institute of Science	Israel	Outreach programmes	science project	all disciplines of science, math, technology, design/ engineering	understanding -4; reasoning -4; reflecting -4; interest – 4; using -4; identifying -4.	Initially, the students are exposed to "activity triggers" on a given scientific topic, to elicit their questions and problems that will evolve into a project proposal. After the proposals are refined and improved, the students work on their projects, with assistance from the teacher and outside experts. They present their projects before an authentic audience from the community.	secondary school pupils	3-4 months
52	Pedra do Sal Environmental Interpretation Centre visit	Pedra do Sal Environmental Interpretation Centre	Portugal	Designed environments	unguided visit	biology; climate; mathematics; history; physical chemistry; geology;	all strands - 5	The activity invites to do species observation in the aquarium. There are some of the characteristic species of the fauna and flora of the Avencas, such as sea urchins, starfish, anemones, among others. Visitors explore the exhibition at their own	general public	1-3 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
						natural sciences		pace, going through each of the modules that the exhibition offers.		
53	Portal do Astrónomo (Astronomer's Portal)	Nuclio Nucleo Interactivo de Astronomia Associacao	Portugal	Technology and media products	website	astronomy, astrophysics, physics, chemistry, mathematics	understanding -4; reasoning -3; reflecting -3; interest -4; using -3; identifying -3.	Portal do Astrónomo is an Astronomy portal where you can find online information about Astronomy and Astrophysics, such as the latest news and discoveries in these fields, as well as resources available in Portuguese and some in English.	general public	n/a
54	Project 19	Co-Lab Mais Atlântico	Portugal	Outreach programmes	science project	science, technology	understanding -5; reasoning -4; reflecting -3; interest -5; using -4; identifying -2.	Students take a scientific article that addresses a current and pertinent ocean problem. They then have to understand the article and select the relevant information, and then create content and turn that information into science communication products. They produce products of different formats: short videos and documentaries, short films, thematic social media campaigns, prime-time news reporting, plays, songs, street-art, painting murals and building facades, etc.	upper secondary school pupils (15-18 y.o.)	1-2 h per week during 6 months
55	PsicoNatura (PsychoNature)	Natura Sottosopra	Italy	Outreach programmes	series of lectures with interactive activities	biology, science of Earth, psychology	understanding -3; reasoning -3; reflecting -2; interest -4; using -3; identifying -2.	This is a programme that tries to combine biology with psychology. Students first attend lessons about the ecosystems that are going to visit after and, at the end of each excursion in a different environment, there is an interactive activity which uses nature as a tool to work with emotions.	upper secondary school pupils	15 h: 4 meetings of 1,5 h and 3 excursions of 3h
56	PsicoNatura (PsychoNature)	Natura Sottosopra	Italy	Outreach programmes	lecture with interactive activities	biology, science of Earth, psychology	understanding -3; reasoning -3; reflecting -3; interest -3; using -3; identifying -2.	This is similar to the programme for children but includes only one visit to an environment.	adults	3 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
57	Ptolemaic and Copernican	Le Nuvole, Cooperativa	Italy	Outreach programmes	lecture with interactive activities	astronomy, physics	understanding -4; reasoning -5; reflecting -5; interest -4; using -4; identifying -5.	It is a participative storytelling. The conductor introduces the topic talking about the theories of Geocentrism and Heliocentrism to provide the audience with a common basic knowledge (30'). At the end he asks to the people "Are you Ptolemaics or Copernicans?" and, when many of them answer, he continues with "Why?" so the debate can start (30').	anyone from 16 y.o.	1 h
58	Radio 3 Scienza (Radio 3 Science)	Radio3 Scienza, Italian National Radio and Television	Italy	Technology and media products	media product	all STEM areas	understanding -3; reasoning -4; reflecting -5; interest -3; using -4; identifying -4.	This is a daily radio broadcast which deals with a wide variety of scientific topics - with particular attention to the most current issues - thanks to the contribution of the experts who are invited each time.	general public	0,5 per programme
59	Roger Penrose's models	Nobel Prize Foundation	Sweden	Technology and media products	website	physics (more widely, all STEM areas)	understanding -3; reasoning -2; reflecting -3; interest -5; using -1; identifying -1.	The goal of the activity is to give an opportunity to dive deep into the "secrets" of the universe. The website presents videos and other digital content about various phenomena, for example black holes.	secondary school pupils	1 h
60	Scenio, science on social media	University of Helsinki, Faculty of Educational Sciences	Finland	Technology and media products	social media	all areas of STEM		Visitors can watch interactive videos about latest science and technology developments.	general public	n/a
61	Science and Reasoning 2000 science club	Science and Reasoning 2000	Israel	Outreach programmes	science club	science, math, computer science and applications, robotics	understanding -2; reasoning -4; reflecting -3; interest -5; using -3, identifying -4.	Students learn about various STEM areas, with each session tailored to the topic at hand. There are about 12-16 students of similar age and abilities who meet once-a-week after school. Instructors are usually university students majoring in STEM disciplines. Lessons generally open with a brief trigger activity (e.g., question, demonstration or video) to arouse interest and elicit students'	primary school children interested in science	30 sessions of 75 min

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
								prior knowledge of the subject to be studied, followed by a hands-on activity done individually or in small groups. Ideally, the final 10 minutes are devoted to sharing findings and conclusions.		
62	Science Lab	University of Twente	The Netherlands	Outreach programmes	workshop	physics, chemistry, biology, technology and engineering	understanding -4; reasoning -4; reflecting -3; interest -5; using -4; identifying -3.	A small intro talk, then some experimental tasks, another talk on a deeper level and then more experiments on a deeper level.	upper primary school children (11-12 y.o.)	2 h
63	Science Wave	Science Wave	Portugal	Technology and media products	media product	neuroscience, immunology, biochemistry, biology	understanding -4; reasoning -1; reflecting -4; interest -5; using -1; identifying -2.	Small stories are presented on Instagram and YouTube that aim at encouraging people to think. They are invited to ask questions or give feedback on posts.	upper secondary school children (15-19 y.o.)	n/a
64	Sem Espinhas (Spineless)	CIIMAR	Portugal	Technology and media products	media product	marine biology	understanding -5; reasoning -4; reflecting -4; interest -4; using -3; identifying -4.	This is a science communication podcast that emerged with the main objective of bringing the non-specialist public closer to the research carried out at CIIMAR I the field of marine biotechnology, aquaculture, oceanography, etc. by making connections with real life.	upper secondary school pupils	20 minutes per episode
65	Space detectives	Nuclio Nucleo Interactivo de Astronomia Associacao	Portugal	Outreach programmes	summer science camp	math, programming	understanding -5; reasoning -5; reflecting -4; interest -5; using -5; identifying -4.	Children are taught some skills, like programming, and then they should solve some problems (e.g., write a note in a binary code).	upper primary school children	1 week
66	Space Scoop	Universe Awareness, Leiden University	Portugal	Technology and media products	media product	astronomy, physics, mathematics	understanding -4; reasoning -3; reflecting -3; interest -5;	Space Scoop brings you the latest astronomy news from across the universe each week. The articles cover all the most exciting cosmic	primary and secondary school children	n/a

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
							using -4; identifying -3.	events in a language that is easy to understand.		
67	Stargazing with a telescope	Nuclio Nucleo Interactivo de Astronomia Associacao	Portugal	Outreach programmes	lecture with interactive activities	physics, chemistry, biology	understanding -3; reasoning -2; reflecting -3; interest -5; using -3; identifying -3.	Different events are organized to present a specific phenomenon (e.g., an exhibition, reciting poetry related to the space theme). Participants first listen to a lecture and then they can observe the sky through the telescope.	secondary school pupils, teachers and parents	2-3 h
68	The Moon and Earth 2022	Cascais Municipal Council NUCLIO	Portugal	Designed environments	unguided visit	astronomy		In this exhibition, we explore the Moon's relationship with Earth, showing how the Moon influences us in many different ways. The posters with information are placed on the embankment so anyone interested in it can have a look.	general public	n/a
69	Tornammo a rimirar le stelle (We came back to look at the stars)	Unione Astrofili Napoletani - UAN	Italy	Outreach programmes	science club	astronomy, astrophysics, physics, geography	understanding -3, reasoning -2, reflecting -5, interest -4, using -3, identifying -4.	Members of the club attend several meetings every month. Each meeting covers a different topic and meetings vary in the type of activities that are provided, for example, lectures, workshops, debates, etc.	club members (adults)	1-2 meetings a month, 1,5-2 h each
70	Touch tank and " A parte que Fica" Exhibition	Pedra do Sal Environmental Interpretation Centre	Portugal	Designed environments	guided tour	biology; climate; mathematics; history; physical chemistry; geology; natural sciences	all strands - 5	Students visit the exhibition and then carry out an activity associated with a specific module of the exhibition. The students' participation is appropriate to their school year and the objectives set by the teacher requesting the visit.	school children of all levels	1-1,5 h
71	Tutti insieme! (All together!)	Fondazione IDIS-Città della Scienza	Italy	Designed environments	designed route with tasks	biology, chemistry, ecology, ethology,	understanding -4; reasoning-3; reflecting -3; interest -4;	An exhibition that shows the behaviour of the social insects colonies. We would like that people understand that the results the insects obtain as a colony are for their	primary and secondary school children	1,5 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
						genetics, math	using -2; identifying-2.	organization. Participants have a guided observation and need to complete a special notebook with questions/tasks.		
72	VIRGO experiment	European Gravitational Observatory	Italy	Technology and media products	online exhibition	physics (more widely, all STEM areas)	understanding -3; reasoning -2; reflecting -2; interest -5; using -2; identifying -1.	Students take part in a virtual visit to the site of the VIRGO experiment, so they get introduced to basic concepts of general relativity and astrophysics, understand the basic structure of the VIRGO experiment and its optical scheme, and perform a treasure hunt inside the interferometer experimental building.	upper secondary school pupils (15-17 y.o)	1,5 h
73	Virtual Solar System	University of Helsinki, Faculty of Educational Sciences	Finland	Outreach programmes	workshop	science		Students are learning about the solar system by using the latest digital technologies.	primary and secondary school children	5 days
74	WE-SEM (SEM – Scanning Electron Microscope)	Weizmann Institute of Science	Israel	Outreach programmes	workshop	physics, chemistry	understanding -5; reasoning -3;. reflection -3; interest -4; using -5; identifying -4.	In the introduction, students learn about the SEM microscope and how it works. Then they engage in experiments with it, with the assistance of scientists. Finally, they see their results and the results of other groups.	upper secondary school pupils	9 h (4.5 h in the lab and 4.5 h via Zoom)
75	Whale exhibition	OMA	Portugal	Designed environments	unguided visit	biology	understanding -4; reasoning -3; reflecting -3; interest -3; using -3; identifying -3.	Visitors observe the exhibition, and learn about whales. A particular section that matches studied material can be visited.	primary and secondary school children	1,5-3 h
76	Xperimenta	University of Twente	The Netherlands	Outreach programmes	workshop	physics, chemistry, biology, technology	understanding -2; reasoning -3; reflecting -1; interest -5;	Children get a one hour intro lecture by a researcher, one hour of experiments - 5 stations with different experiments related to the topic, each	lower primary school	2 h

	Activity name	Activity provider	Country	Context	Activity type	STEM areas	Contribution to the SP strands	Description	Target group	Intended time
						and engineering	using -2; identifying -2.	requires ~10 minutes. Children complete one station and move to the next, they are assisted by university students.	children (8-10 y.o.)	

3 Selection of case studies

From the inventory, case studies were selected for detailed analysis and research. This chapter presents the approach that was used to select the case studies, the selection criteria, and the final selection.

3.1 Approach to activities selection and selection criteria

When selecting case studies, we had three goals in mind. The first goal was to come to a selection that represents a large variety of iSTEM activities. The second goal was to go for activities that meet (some of) the success criteria identified in D2.2 (see more information below). Finally, we aimed at choosing cases that are practical in terms of data collection.

To serve the first goal, we determined which categories in the description of the activities needed to be taken into account. These are the categories and their considerations:

- Context – all three learning contexts (outreach programmes, designed environments, and technology and media products) should be equally represented.
- Activity type – within one learning context, activities of different types should be chosen if possible.
- Activity provider – activities provided by internal providers (i.e., project members) and external providers (i.e., not project members) should be included. The rationale behind including internal activity providers was to use consortium expertise in the area of creating iSTEM learning activities, while the rationale for including external activity providers was to also cover activities developed outside the consortium. Apart from internal and external, we distinguish semi-internal – activities provided by a different department or section of the project-member organisation.
- STEM area – activities covering different STEM areas should be presented.
- Country – according to the proposal, geographical coverage of the research activities should include at least six countries.

The second goal was connected with key design characteristics of the activities – it was desirable that at least some of the success criteria were met according to the description given by the activity provider. Success criteria for each learning context, as they were identified in D2.2, are presented in Table 5 (see D2.2 for more information about how these success criteria were identified). The rationale behind this requirement was based on the understanding that successful activities would have more impact on participants' science proficiency development, therefore, research on these activities is expected to be more informative. However, it was not necessary for an activity to meet all the criteria to be selected, because of two reasons. The first reason was that depending on the goals and target group, some success criteria may be less relevant for a specific activity. The second reason was of practical nature – the project aims to study activities representing the real situation, so if some well-designed existing activities still miss some success criteria, they should be studied and recommendations should be formulated based on this.

Table 5. *Success criteria per learning context*

Outreach programmes	**Designed environments**	**Technology and media products**
1.Connection to real life	1. Connection to real life	1. Accessible/ easy to use
2. Choice of topic	2. Choice of topic	2. Connection/relevance to real life
3. Encouraging curiosity/ questioning/ inquiry	3. Encouraging curiosity/ questioning/ inquiry	3. Encouraging curiosity/ questioning/ inquiry

4. Personal experience/ interest-based	4. Combining visual, audial and kinaesthetic information and activities	4. Visually attractive (design)
5. Interactivity	5. Active involvement/ interactivity	5. The way of presenting information (for media products)
6. Collaboration/ dialogue with peers	6. Visually attractive materials	6. Interaction with the audience/ active engagement (for media products)
7. Age- and ability-appropriate language and tasks	7. Authentic materials	
	8. Collaboration/ family learning	
	9. Age- and ability-appropriate language	

To serve the third part of the goal, practical considerations were applied to the selection process. They included the following:

- The activity should be running in the coming months (November 2022 – July 2023).
- There is a preliminary agreement with the activity provider to include this activity in the research.
- There is a way to organise data collection either by the project team (there are consortium members in this country who can collect data on site) or by the activity providers themselves (and they are willing to do so).

Moreover, instead of choosing 15 case studies (five per learning context) as it was mentioned in the proposal, it was decided to choose 18 (six per learning context). This was done to provide more flexibility with data collection forms and time, as well as to ensure at least five case studies per context in case of unforeseen circumstances. Obviously, there is always the possibility that some activities are not available for data collection due to problems that are not known or predicted at this moment. In this case, they will be replaced by activities that are as similar as possible to the ones presented in this document.

3.2 Selected case studies

This section describes the selected case studies for each context.

3.2.1 Outreach programmes

1. Scenario-based activity “Chemistry escape room” (N 12 in the inventory)

Activity provider: Weizmann Institute of Science, Israel

The activity is meant for upper secondary school pupils and encourages them to apply their knowledge of chemistry to solving puzzles and problems. Students work in groups in a lab to find clues and solve chemistry problems to find the way out of the room. The tasks are based on the material studied at school. The themes focus on energy and sustainability, the periodic table, and acid-base reactions.

The activity targets increasing students’ interest in and motivation to learning chemistry, as well as contributing to their understanding of chemistry, applying its language and tool, and practising scientific reasoning. This is fully in line with the priorities of the activity provider in terms of developing science proficiency: interest, scientific reasoning and using the language and tools of science.

2. Science project “The community of the beach” (N 29 in the inventory)

Activity provider: Associazione di Ricerca e Divulgazione per l'Educazione Ambientale (ARDEA), Italy

The activity targets primary school children and consists of a programme of different meetings in which children start as learners as they listen to the explanation about habitat and species. Then they become researchers, as they monitor the species, analyse the beach and all its inhabitants. And finally, they take the role of politicians by writing rules for a correct use of beaches. The main goal is letting children experience that they are able to change things.

The activity contributes to developing interest to science but also scientific reasoning and seeing the consequences of actions in everyday life. Through this, children acquire a more active role in citizen science and start identify themselves with the scientific enterprise, which is one of the priorities of the activity provider.

3. Workshop “Maker Space” (N 35 in the inventory)

Activity provider: Nuclio Nucleo Interactivo de Astronomia Associacao, Portugal

The activity is meant for anyone interested in modern technologies and science and covers various STEM topics depending on the participants’ choice. Workshops in the Maker Space aim at bringing science closer to the community and empowering citizens with innovative and creative STEM competences. Participants work in groups or individually for four to six hours to create a product following the theme.

The activity contributes to the development of scientific reasoning and using tools of science, which is in line with the organisation goals.

4. Series of workshops “Master class” (N 36 in the inventory)

Activity provider: Pre-U programme, University of Twente, The Netherlands

The activity is meant for upper primary school children (11-12 years old) and includes three workshops of two hours each given in three consecutive weeks. The first week is an introduction of the topic by university students. During the second week, school children are divided in groups and each group works independently to conduct several experiments about the topic. The third week is devoted to developing a product based on the obtained knowledge on this topic. Finally, there is a small concluding part when groups presents their projects.

This activity focuses on developing interest to science, understanding of and reasoning about scientific phenomena, with a bit less attention spent on using tools and language of science, reflecting on science and identifying with science. This perfectly fits the organisation goals in terms of contribution to science proficiency, as the top three are developing children’s interest to science, their ability to use the language and tools of science, and to reflect on it.

5. Workshop “Observation nights” (N 48 in the inventory)

Activity provider: Ellinogermaniki Agogi Scholi Panagea Savva AE (EA), Greece

The activity is meant for general public and aims at providing hands-on experience in astronomy. Participants conduct observations of Jupiter and Saturn by using a modern telescope. They also gather evidence of their observations (e.g., digitally processed images of Jupiter and Saturn) and then compare their observations with the ones made by Galileo. Users also learn how to build their own telescope (hands-on activity with simple materials) and use the Stellarium Astronomy Software (https://stellarium.org/) to perform observations of Jupiter and its moons and compare those observations with the ones made by Galileo.

The activity contributes to developing interest to science through an authentic research experience, which aligns with the priorities of the activity organisation.

6. Science club “We came back to look at the stars” (N 69 in the inventory)

Activity provider: Unione Astrofili Napoletani, Italy

The science club is meant for the members of general public who are interested in astronomy. There is a list of events that club members can attend every month (either all events or choose the ones that fit their interests). The type of events vary but they are only for the club members. An example of such an event is a lecture with interactive elements. Participants start with a live show in the planetarium theatre where they are guided to visit different celestial bodies of the sky. They have an opportunity to study the images obtained with the help of last-generation telescopes, take part in a debate and observe the sky themselves under supervision of a presenter.

The activity aims at increasing visitors’ interest in science and their ability to reflect on it, which brings science closer to people and contributes to their identification with the scientific enterprise. That fits the organisation profile as prioritising motivation to and excitement about studying science.

3.2.2 Designed environments

1. Unguided visit to Corporea exhibition (N 13 in the inventory)

Activity provider: Fondazione IDIS-Città della Scienza, Italy

Targeting general public, this exhibition is dedicated to the human body and its functions with particular attention to health. Visitors are invited to interact with stands in nine thematic islands arranged according to the different systems of the human body and to observe what happens and what consequences particular actions have.

The activity contributes to developing interest in science and equipping participants with more knowledge.

2. Unguided visit to De Vlinderfabriek (The Butterfly factory) (N 16 in the inventory)

Activity provider: The Museumfabriek, The Netherlands

During this activity, families with children and general public can learn about butterflies, starting from a biological point of view (e.g., what type of butterflies exist, how they develop from cocoon to a butterfly), to an ecological point of view (e.g., what is the role of butterflies in nature), and even a technological point of view (how can butterfly fly).

The activity meant for 1,5-2 hours helps to develop interest in science as well as knowledge, which is supported by the organisation priorities.

3. Unguided visit to the Nordhorn zoo (N 47 in the inventory)

Activity provider: Tierpark Nordhorn, Germany

To study different ways of people’s interaction with iSTEM learning, an unguided visit to the zoo is included in the selected cases. Such visit is meant for general public with the majority of it being families with children. There is no specific route that visitors should take, so they can follow their interests. Visitors can see different animals and read information boards about them. There is a pet zoo, where small children can touch and pet animals. This activity mainly contributes to developing public’s and especially children’s interest in animals and through that raise more knowledge and awareness about biology and ecology, and their influence on everyday life. Interest and knowledge are exactly two strands of science proficiency that are considered by this activity provider to be top priorities for this organisation.

4. Unguided visit to Pedra do Sal Environmental Interpretation Centre (N 52 in the inventory)

Activity provider: Pedra do Sal Environmental Interpretation Centre, Portugal

The activity is meant for anyone interested in the flora and fauna of the Avencas. Visitors can observe species in their recreated habitat and read information provided. There are also some interactive stands that allow exploration at one's own pace.

During the visit that can last up to three hours, the public is introduced not only to the topics of biology but also climate change, geology, chemistry and others.

5. Guided tour at Touch tank (N 70 in the inventory)

Activity provider: Pedra do Sal Environmental Interpretation Centre, Portugal

This activity is based on the exhibition developed for general public but focuses on a specific module, depending on their age group and curricula. During a guided tour students visit a part of the exhibition and discuss this in connection to the material studied in school. Even though this activity is meant for one or one and a half hour, it contributes not only to students' interest in science but also to their understanding of scientific phenomena and reasoning about them.

6. Designed route with tasks "Tutti insieme!" (All together!) (N 71 in the inventory)

Activity provider: Fondazione IDIS-Città della Scienza, Italy

The activity is meant for primary and middle school pupils visiting the exhibition about ants as social animals with their teachers. During 75-90 minutes, pupils listen to the guide, observe and sometimes even touch the insects, read information panels, and watch videos. They also need to answer questions and complete tasks in a special notebook. At the end of the activity, they talk about their experience with insects and what they have learned. Learning about the behaviour of the social insects colonies, pupils get introduced to topics from biology, chemistry, ecology, ethology, genetics, and math. Tasks and questions in the notebook differ per age group as they correspond to the material studied in school. In this way, the activity connects learning in formal and informal settings.

This activity mainly contributes to sparkle students' interest to science and develop their understanding of social animals, with a bit less contribution to developing scientific reasoning and reflection. This fits IDIS profile as a science museum with their priorities in terms of contribution to science proficiency being developing interest to science, engaging in scientific reasoning and understanding scientific content.

3.2.3 Technology and media products

1. A virtual visit to Galileo museum (N 3 in the inventory)

Activity provider: Galileo museum, Italy

This activity is meant for secondary school pupils and aims at bridging a gap between modern discoveries and the heritage scientists in the past. During the virtual visit to the Galileo Museum in Florence students explore the discoveries and the archives of Galileo Galilei through different access modes. They can personalise their experience, by repeating the experiments of Galileo through innovative tools that are available today (e.g., studying sunspots through real-time access to solar data through the SOHO space telescope) and comparing them with the images Galileo made in 1610.

This activity sparkles students' interest in science and contributes to their understanding and using of the tools and language of science, which fits the organisation goals.

2. Website of Davidson Institute (N 15 in the inventory)

Activity provider: The Davidson Institute, Weizmann Institute of Science, Israel

The website presents a whole series of small activities covering all areas of STEM and targeting school children of different ages. The Davidson Institute has run a very successful online informal

science platform for many years. It was especially successful during the COVID-19 pandemic. "Stuck at Home" includes trivia games, videos, online courses, science experiments, etc. "Science Video on Demand" includes other video products. Visitors of the website can either browse activities of the same type or topic, or jump from one type/topic to another. This way they learn about science in everyday situations or the influence science has on everyday life.

This activity is meant to form and maintain children's interest in science and scientific phenomena.

3. A website with "MOOCs about recreational math" (N 38 in the inventory)

Activity provider: The Davidson Institute, Weizmann Institute of Science, Israel

The activity targets general public and allows to learn about math for leisure at one's own pace. Taking part in a course (there are three of them) participants engage in the recreational side of math, i.e., the mathematics of bar codes, puzzles, codes, roman numerals, Egyptian hieroglyphics. Each course covers twelve hours and can be taken either separately or as part of the whole package.

This activity aims at increasing interest in math and understanding its connection to everyday activities among general public. This fits the priorities of the organisation which focuses on developing interest in science.

4. A website with an online game "The mystery in the forest of Østmarka" (N 43 in the inventory)

Activity provider: Vitenparken, Norway

The activity aims at changing misconceptions that secondary school pupils may have about big predators by providing them with information about such animals and allowing to see a bigger picture through a game-based simulation. The mystery part is that a dead deer has been found in the woods, obviously killed by an animal. The children must collect data as a scientist/wildlife manager to figure out what kind of animal killed the deer, options being a dog, lynx or wolf. During the story, the children are presented with information about the three predators such as tracks, typical movement pattern, and skull. Depending on the data they find, they have to try to deduce which animal they have been tracking.

This activity contributes to knowledge development as well as interest in science.

5. A website with videos about Roger Penrose's models (N 59 in the inventory)

Activity provider: Nobel Prize Foundation, Sweden

The activity is meant for secondary school pupils who want to dive deep into the "secrets" of the universe by learning about black holes, one of the most exotic phenomena in the universe. They can do so by watching videos and accessing other digital content available at the website of the Nobel Prize Foundation. For example, they can learn about Roger Penrose, Nobel Laureate in Physics 2020, and his ingenious mathematical models to explore Albert Einstein's General Theory of Relativity which showed that black holes are a direct consequence of that theory.

This activity contributes to maintaining the interest in science and acquiring more knowledge and understanding of scientific phenomena, which is in line with the organisation priorities.

6. A virtual visit to the VIRGO experiment (N 72 in the inventory)

Activity provider: European Gravitational Observatory, Italy

This activity gives upper secondary school pupils the possibility to learn more about the VIRGO experiment. They get introduced to basic concepts of general relativity and astrophysics, so they can better understand the basic structure of the VIRGO experiment and its optical scheme. As a more interactive element, they also perform an online treasure hunt inside the interferometer experimental building, and have a chance to discuss live with a scientist how the first-ever

observation of gravitational waves (2015) happened and why it was awarded the Nobel Prize in Physics 2017.

This activity stimulates participants' interest to science and understanding complex matters through seeing authentic state-of-the-art equipment.

3.2.4 Learning pathway

Some of the selected cases present activities that can also constitute parts of a wider whole, i.e., the iSTEM learning pathway "From Galileo to Gravitational Waves and Back". These activities are: a virtual visit to Galileo museum (N 3 in the inventory), workshop "Observation nights" (N 48 in the inventory), a website with videos about Roger Penrose's models (N 59 in the inventory), and a virtual visit to the VIRGO experiment (N 72 in the inventory).

Learners complete these activities in a specific order to explore and make sense of the thread that connects the past, present, and future of science and technology. The path illustrates scientists' never-ending quest to understand the fundamental laws that govern our universe (a detailed presentation of this pathway is given in D2.1, pp. 18-21). Following this path, participants can build on the knowledge and understanding gained in previous activities to dive in the topic further. The project team intends to study these cases separately, similar to the other cases described above, as well as a whole pathway to see the impact of several connected iSTEM activities.

4 Conclusions

The end goal of this document was to present the selection of 15 cases that will be studied from different research perspectives in the coming years of the project. In order to come to a good and justified selection, the process of reaching this point has been described.

The first step was to gather a wide range of different example activities. This overview was made in the form of an inventory in which key information about each activity has been given. The inventory includes 76 activities, which is more than the targeted 60 activities promised in the proposal. The information about the activities was collected by conducting interviews with activity providers, using expertise of project members, and scanning recent events in the field of iSTEM learning.

Before starting the data collection, it was important to define what kind of information was needed to describe activities in the inventory. This information should give a good base for the selection process later. The following pieces of information were included: the name of the activity provider, the country in which the activity takes place, the learning context (i.e., outreach programmes, designed environments, or technology and media products), the activity type as identified and described in D2.2, the STEM area(s) that the activity covers, the contribution to the six science proficiency strands as described in D2.1, a description of the activity, the intended target group, and the time intended for the activity. All information, except from the learning contexts and activity types, which were based on the work presented in D2.2 *Surrounded by Science Key Characteristics and Matrices,* came from the activity providers.

After completing the inventory, the selection process started. It was decided to choose 18 cases instead of 15 declared in the proposal to ensure that at least 15 cases can be studied. The approach to nominate activities for further research was to make the collection as broad as possible according to the categories of the inventory (i.e., learning context, activity type, etc.). Together with content-related criteria, there were also practical considerations: the activity should be running in the coming year and there should be a possibility to collect data for this activity. Table 6 presents an overview of the selected case studies with information about selection criteria described in Section 3.1 of the current document.

Table 6. *Overview of selected case studies*

Activity name	**Context**	**Activity type**	**STEM areas**	**Target group**	**Provider**	**Country**
Chemistry escape room	Outreach programmes	scenario-based activity	chemistry	upper secondary school pupils	internal	Israel
The community of the beach	Outreach programmes	science project	biology, zoology, botany, geology, ecology	primary school children	external	Italy
Maker Space	Outreach programmes	workshop	all areas of STEM	anyone above 6 y.o.	internal	Portugal
Master class	Outreach programmes	a series of workshops	physics, chemistry, biology, technology and engineering	upper primary school children (11-12 y.o.)	semi-internal	The Netherlands

Activity name	Context	Activity type	STEM areas	Target group	Provider	Country
Observation nights	Outreach programmes	workshop	astronomy	general public	internal	Greece
We came back to look at the stars	Outreach programmes	science club	astronomy, astrophysics, physics, geography	club members (adults)	external	Italy
Corporea exhibition	Designed environments	unguided visit	life sciences; human body and health	general public	internal	Italy
De Vlinderfabriek	Designed environments	unguided visit	biology, environmental studies	families	external	The Netherlands
Nordhorn zoo	Designed environments	unguided visit	biology, ecology	general public	external	Germany
to Pedra do Sal Environmental Interpretation Centre	Designed environments	unguided visit	biology; climate; mathematics; history; physical chemistry; geology; natural sciences	general public	external	Portugal
Touch tank and " A parte que Fica" Exhibition	Designed environments	guided tour	biology; climate; mathematics; history; physical chemistry; geology; natural sciences	primary and secondary school children	external	Portugal
Tutti insieme! (All together!)	Designed environments	designed route with tasks	biology, chemistry, ecology, ethology, genetics, math	primary and secondary school children	internal	Italy
Galileo museum	Technology and media products	online exhibition	all areas of STEM	secondary school pupils	external	Italy
Davidson's Institute website	Technology and media products	website	all areas of STEM	school children of all ages, general public	semi-internal	Israel
MOOCs about recreational math	Technology and media products	website	math	general public	semi-internal	Israel

Activity name	Context	Activity type	STEM areas	Target group	Provider	Country
The mystery in the forest of Østmarka	Technology and media products	website (online game)	biology, ecology	secondary school pupils (10-14 y.o.)	external	Norway
Roger Penrose's models	Technology and media products	website	physics (more widely, all STEM areas	secondary school pupils	external	Sweden
VIRGO experiment	Technology and media products	online exhibition	physics (more widely, all STEM areas)	upper secondary school students (15-17 y.o)	external	Italy

The final list of cases is presented in this document with a brief description of each activity. This list, along with other products, summarises the work of Work Package 2 and serves as an input for the second phase of the project – Research phase. These activities will be researched and conclusions and recommendations will be made based on the obtained results. This means that it feeds the work of several work packages – Research implementation (WP4), Impact assessment (WP5) and Digital toolbox (WP3).