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COM n PLAY SCIENCE

PROJECT DELIVERABLE – PUBLIC

D1.1 COMnPLAY SCIENCE CONCEPTUAL AND METHODOLOGICAL FRAMEWORK

v. 4.0

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PROJECT FACT SHEET

Acronym
COMnPLAY SCIENCE

Full Title
Learning science the fun and creative way: coding, making, and play as vehicles for informal science learning in the 21st century

Programme / Pillar / Topic
Horizon 2020 / Science with and for Society / Science education outside the classroom

Type of Action
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Overview
The project aims to help Europe better understand the new ways in which informal science learning is taking place through various coding, making, and play activities that young Europeans (children, adolescents and young adults) are nowadays increasingly engaged with, outside school and higher education science classrooms, beyond the formal boundaries of science education.

The project's main objectives are to:

a. Develop an appropriate conceptual and methodological framework integrating all aspects of the project into a unifying conceptual map.
b. Setup a European-wide community of stakeholders, including learners, educators, facilitators and policy makers from diverse fields, to contribute, guide and help assessing the conducted research.
c. Identify, pool and analyse diverse existing coding, making and play-based practices taking place outside formal science classrooms which bear some promise for informal science learning.
d. Conduct in-depth learner-centred participatory empirical research on selected practices.
e. Gain a deep understanding of the impact that this kind of informal science learning has on formal science education, traditional informal science learning interventions, young people as learners and citizens, as well as, on society.
f. Communicate and disseminate the messages and outcomes of the project widely, and enable the exploitation of the findings of the research through the development of relevant guidance for practitioners and recommendations for policy development and further research.

The main results stemming from the project include:

- An online inventory of all the identified and pooled practices, appropriately categorized and annotated in the light of the findings of the research, available to stakeholders and the public.
- A set of community building methods and tools for everyone wishing to get involved in community building linked to the project.
- A Web-based game promoting and supporting the continuous prolonged engagement of learners and their facilitators in the field research.
- The *COMnPLAY SCIENCE Knowledge Kit*, a modular set of reader-friendly, practice-oriented publications, encapsulating the findings of the project.
- The *COMnPLAY SCIENCE Roadmap for Europe*, a detailed concerted account by the consortium, the stakeholder communities and policy makers of the potential for short-, medium- and long term impact of coding, making and play-based informal science learning.
- Numerous public events (workshops, training seminars, conferences, contests, fairs), often combined with training activities (winter and summer schools).

Project Coordinator

Norwegian University of Science and Technology (NTNU)
Prof. Michail Giannakos
Phone: +47 73590731
E-mail: michailg@ntnu.no

Consortium Members

Norwegian University of Science and Technology, Norway (coordinator)	University of Oulu, Finland	Foundation for Research and Technology – Hellas, Greece
Eindhoven University of Technology, Netherlands	Uppsala University, Sweden	Technical University of Munich, Germany
University of Malta, Malta	Design for Change initiative, Spain	ovos media GmbH, Austria
King's College London, UK	Science Museum Group, UK	

Web & Social media

Web Site: http://comnplayscience.eu Facebook: https://fb.me/ComNPlayScience
YouTube: https://bit.ly/2Hq5FsK Twitter: @comnplayscience
ResearchGate: https://www.researchgate.net/project/CoM-n-Play-Science

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Executive Summary

This document reports on the outcomes of Task 1.1 'Conceptual framework' and partially of Task 1.2 'Methodological framework' of the COMnPLAY SCIENCE project, presenting the Conceptual and Methodological Framework of the research, as those have been shaped and are available at the end of the fifth project month (M5, October 2018).

The Conceptual Framework, a more 'theoretical' part of the report, maps and organizes the central concepts of the project. Based on this, the Methodological Framework becomes more practical, providing the methodological design, i.e. a general description of the methodological approach of the project, reflecting the overall conception of the research as well as the realities and practicalities of the field as they have been recorded up to the time of delivery of the present report.

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1. Introduction

The present report constitutes the deliverable D1.1 'Conceptual and Methodological Framework' of the COMnPLAY SCIENCE project. It reports on outcomes of Tasks 1.1 and 1.2 of WP1 as those have been shaped and are available at the end of the fifth project month (M5, October 2018).

The report consists of two major parts: the Conceptual Framework presented in section 2, and the Methodological Framework in section 3. The Conceptual Framework, a more 'theoretical' chapter of the report, maps and organizes the central concepts of the project. Based on this, the Methodological Framework becomes more practical, providing the methodological design, i.e. a general description of the methodological approach of the project, reflecting the overall conception of the research as well as the realities and practicalities of the field as they have been recorded up to the time of delivery of the present report.

1.1 Defining the conceptual baseline and methodology of the project

Thus far, Task 1.1 'Conceptual framework' has defined the conceptual baseline of the project, taking stock of knowledge available both within the COMnPLAY SCIENCE consortium and beyond. In parallel, Task 1.2 'Methodological framework' has been operationalising this conceptual framework into a methodological design for the realisation of the activities that will take place in the subsequent project phases.

In this ongoing process of defining the conceptual and methodological background of the research, the first milestone is the completion and delivery of the present report, which defines the conceptual framework and the methodological design at a high level. Following this first step, the refinement of the methodological design and the development of the corresponding methodological tools are continued, to lead eventually to the second milestone in this process, i.e. the delivery of deliverable D1.2 'Research Instruments and Tools' by the end of M8. The process leading to the next report (D1.2) will further define and clarify some concrete aspects, in particular, of the methodological design, providing the relevant concluding decisions of the consortium – at least for this stage of the project, since the consortium may be revisiting aspects of the methodology in the future, when and as required, so as to adjust the research to the emerging realities on the field.

1.2 Interrelation with WP2 'Practices'

The approach adopted for the preparation of the Conceptual and Methodological Framework prioritised linking the general assumptions and intentions of the project with the very diverse realities of the informal science learning practices that the project intends to investigate on the field. Therefore, work presented in this report clearly also relates to WP2 'Practices', contributing a starting point for the identification, pooling (Task 2.1) and selection (Task 2.2) of the practices to be studied.

Using the Template for the Identification of the Consortium's Own Practices included in Annex A of this report, the consortium has identified and gathered the first descriptions of practices that the consortium considers as very relevant to the research and to which consortium partners may have immediate or relatively easy access for the purposes of the empirical research (WP3). This information has helped refine the focus of the Conceptual Framework, and, in particular, define a realistic Methodological Framework by taking into account practicalities of the field, such as practice availability, access to participants, etc.

These first identified practices, referred to as "the consortium's own practices", are presented in section 3.1.5. Based on this background, Task 2.1 'Identification and Pooling of Practices' can go deeper into the consortium's own practices, defining them in more detail, as well as identifying, inviting and motivating others beyond the consortium to contribute their practices to the project.

2. Conceptual Framework

The present section, the Conceptual Framework of the COMnPLAY SCIENCE project, maps and organizes the central concepts of the project. It presents the research aims and focus, the science learning and education concepts touched upon, and the research questions that the project is seeking to answer.

2.1 Research aims and focus

The COMnPLAY SCIENCE project aims to help Europe better understand the new ways in which informal science learning is taking place through various coding, making, and play activities that young Europeans (children, adolescents and young adults) are nowadays increasingly engaged with outside school and higher education science classrooms, beyond the formal boundaries of science education.

The project aims to investigate a wide range of loci and modes of this kind of informal science learning, including:

- learning happening in the context of such activities intentionally organized to achieve aims overtly related to informal science learning (e.g. in science centres, etc);
- informal science learning that occurs as a by-product of youngsters' various coding, making, and play activities that are not intentionally meant as science learning activities, and which may take place:
    - in organized contexts (e.g. fabrication labs, coding labs, etc), as well as
    - independently in everyday life (e.g. personal hobbies and projects, gaming, etc).

Carefully positioning the research within the context of the overarching contemporary discourses on Science, Technology, Engineering, (Arts) and Mathematics (STEM/STEAM) education, Responsible Research and Innovation (RRI), as well as research on Science Capital, the proposed project aims to shed light on the nature and impact of the informal science learning gained through coding, making and play activities, and offer its findings to the European public in ways that will inform, inspire and motivate next steps in field practice and policy making.

2.1.1 Research on the nature of informal science learning

In exploring the nature of this kind of informal science learning, the project has already started identifying several and diverse coding, making and play-based practices taking place outside formal science classrooms which nevertheless appear to bear some promise for informal science learning (cf. section 3.1.5 of this report, and Task 2.1 / deliverable D2.1).

Subsequently the project will look into a selection of those practices (cf. Task 2.2 / deliverable D2.1), whereby young people involved in real-life cases of implementation of such activities and their facilitators are surveyed, observed, and gamefully engaged in intensive self-reflective participatory research, so that the project can investigate the following aspects in depth (cf. Task 3.1 / deliverables D3.1 and D3.2):

- The conceptual and procedural relations, and complementarity within the ecology of science learning, among:
  a) the knowledge, attitudes, experiences and resources gained through coding, making, and play activities;
  b) the knowledge that is mainly the aim of formal science education; and
  c) the science-related attitudes, experiences and resources that are mainly supported by out-of-school learning opportunities, families and communities.
- The extent to which, and specific ways in which various aspects of a young person's science capital can actually be enriched through their engagement in different making, coding, and play activities in organized contexts and in everyday life, including both activities which may from their conception intend to achieve a kind of informal science learning outside the classroom, and indeed activities which may not be originally intended towards science learning at all (cf. section 2.2.1, for more on the use of the social capital concepts in this project).

2.1.2 Research on the impact of informal science learning

Based on this new understanding of the informal science learning gained through coding, making, and play activities, the project further aims to explore the existing and potential impact of this kind of informal science learning on science education and society (cf. Tasks 3.2 and 3.3 / deliverable D3.3), by looking into:

- The effects that this kind of informal science learning may have on formal science education as well as on more traditional informal science learning interventions, focusing on:
  - possible tensions but also synergies between them and their complementary roles, paying particular attention to ways in which such activities can succeed in supporting young people to develop their personal interests in science where the field of the science classroom might not work very well for some individuals;

    - the opportunities and challenges that may arise in future attempts to 'formalise' such informal science learning through the assessment of the science-learning-related quality of the content of relevant activities and the accreditation of the science-related gains in knowledge, dispositions and behaviours through such activities.
- The contribution of this kind of informal science learning towards scientific citizenship, focusing in particular on:
    - the attitudes, values and dispositions that young people as learners and as citizens may develop through such activities towards science, scientists, and science-related information in everyday life
    - the resulting potential for more scientifically informed behaviours and decisions by young people as consumers and citizens
    - the resulting potential for young people's involvement in citizen science
    - the resulting potential for a better linking of science to societal needs and concerns.

2.1.3 Inspiration for further practice and policy making

As described above, the research has started with the identification of various coding, making and play-based practices, a selection of which will subsequently be analysed in-depth.

All the identified practices, appropriately categorized and annotated in the light of the findings of the research, will eventually be offered to the public in an online inventory, and actively publicised through social media, so that they can be further disseminated and exploited in the world of science learning (cf. Task 2.3 / deliverables D2.2 and D2.3).

By producing a wealth of evidence across a broad range of contexts, the project will eventually provide Europe with an array of identified good practices of informal science learning occurring in the context of coding, making, and play activities, as well as with a deep understanding of the impact that this kind of informal science learning has on formal science education, on traditional informal science learning interventions, on young people as learners and citizens, and on society more widely.

This will enable European societies and economies to develop innovative coding, making, and play related initiatives, products and services, with a stronger science learning effect and a clear link to RRI concerns and societal needs, readily available to meaningfully and purposefully enrich and innovate formal science education and traditional informal science learning interventions.

Importantly, the consortium aims to finally deliver all these findings and outcomes in a comprehensive set of communication events and publications appropriately addressing to the various stakeholder and policy making communities (cf. Task 4.3 / deliverables D4.3, D4.4, D4.5; and in particular D4.6, the COMnPLAY SCIENCE Knowledge Kit and Roadmap for Europe, a modular set of reader-friendly, practice-oriented publications).

2.1.4 Identity and type of activities

2.1.4.1 Creative and playful science learning outside the classroom

In recent years there has been an upsurge in the interest in using creative and playful practices and activities to enrich learning experiences and boost learners' engagement in the learning process. The COMnPLAY SCIENCE project looks at practices and activities of this type as vehicles for science education outside the science classroom, what, for ease of reference and in line with usual practice in the field of science education, in this project we collectively call 'informal science learning'(ISL).

Nevertheless, the project does observe the stricter distinction between non-formal and informal science learning, and looks into both types of learning spaces (see more on this in section 2.1.4.4 further below) juxtaposing them with formal science education.

2.1.4.2 A focus on coding, making, and play

In the broader landscape of creative and playful science learning outside the classroom, the COMnPLAY SCIENCE project chooses to focus in particular on informal science learning linked with coding, making and play-based activities. A short overview of these three areas of activity, and the rationale for this focus, are provided in the following sections.

CODING

Teaching coding to turn youngsters into confident and creative developers of digital solutions is currently gaining momentum in classrooms and informal learning spaces (coding fairs, labs, challenges, etc) across the world. In 2013, the UK introduced a coding curriculum for all school students (Department for Education, 2013); since then, several other European countries have been moving in the same direction. In the USA, a number of organisations (e.g. the acclaimed Code.org initiative) support computer programs in schools and offer coding lessons for everyone. Such new curricula and out-of-classroom initiatives are aiming far beyond just creating a new generation of computer programmers as a response to changing global demands for workplace skills. The purpose is to provide young people with the tools to navigate digital landscapes effectively, by developing their technological fluency and deeper understanding of how the digital world is created, how it might be used to meet our needs, how we might repair or modify it.

MAKING

The maker movement of independent innovators, designers and tinkerers has also dynamically entered the landscape of innovative education and informal learning. In makerspaces mushrooming in schools as well as in science centres, libraries, museums and other informal learning spaces, more and more young makers are developing projects focused on prototyping innovations and repurposing objects. Maker education is emerging as a topical approach to interdisciplinary problem-based and project-based learning entailing hands-on, often collaborative, learning experiences, and making in learning spaces and the positive social movement around it are seen as an unprecedented opportunity for educators to advance a progressive educational agenda. In the USA, the Obama administration strongly supported the growing maker movement as an integral part of STEM education, hoping to increase American students' ability to compete globally in the areas of science, engineering, and math.

The two movements, coding and making, are converging around the notion of digital fabrication, often linked to other technology-related learning activities such as those pertaining to robotics. Digital fabrication has dynamically entered the worlds of education and informal learning, boosted by world-wide FabLab initiatives (e.g. Stanford's FabLearn Labs, formerly FabLab@School). These educational digital spaces for invention, creation, inquiry, discovery and sharing put cutting-edge technology for design and construction into the hands of young people so that they can "make almost anything", thus supporting project-based student-centered learning integrated into personal interests and daily life.

PLAYFUL ACTIVITY

Across the spectrum of these emerging creative learning spaces, the elements of fun and playfulness are dominant. Especially outside classrooms, in the inviting and open-ended informal learning atmosphere of science centres, museums, libraries, zoos, community labs, outreach centres, fairs, contests, etc, playful learning is the norm. There, fun creative learning activities harness children's sense of joy, wonder and natural curiosity, achieving high levels of engagement and learner's personal investment in learning. In a sense, in these informal learning spaces young people discover or re-invent their true selves as natural scientists, mathematicians, or artists constantly seeking to construct new meaning and make sense of the world around them. Thus next to and far beyond game-based learning in science education (Li & Tsai, 2013), whereby learning content and processes are incorporated in gameplay, in coding and making activities pure learning through play finds very fertile ground: as the seminal work by LEGO Foundation (The LEGO Foundation, 2017) puts it , "learning through play happens when the activity (1) is experienced as joyful, (2) helps children find meaning in what they are doing or learning, (3) involves active, engaged, minds-on thinking, (4) as well as iterative thinking (experimentation, hypothesis testing, etc.), and (5) social interaction." This is exactly what is happening when young people code and make in the context of playful informal science learning experiences.

2.1.4.3 Why this focus

The rationale behind the focus of the project on informal science learning linked with coding, making and play-based activities is threefold:

First, while there is substantial knowledge already broadly about informal science learning and science education outside the classroom [e.g. (Lloyd, Neilson, King, Mark Dyball, & Kite, 2012) (Falk, et al., 2012) (Robelen, et al., 2011)], what is still needed, especially at the European level, is much deeper insights into the nature and multifaceted impact of this type of learning. Gaining such deeply probing insights within the time and resources provided requires a focus on specific areas of the broader field, which will yield results that can then both be extrapolated and guide further research in other neighbouring areas.

Second, among the various informal science learning spaces and practices, much attention has been given to experiences and activities characteristically (one could also say, traditionally) associated with science museums and centres, zoos, exhibitions, competitions, field visits, etc. However, the increasing emergence and proliferation of practices emphasizing the fun and creative element of informal science learning, as these are characteristically exemplified in coding, making and play-based activities, have not yet drawn enough focus on them, while appearing to be one of the new 'big things' in the field.

Third, the links and contributions of coding- and making-based creative learning activities to science education are strong and intuitively obvious, albeit still only little explored and understood in depth. To a conservative approach to science education, coding and making may appear to lie beyond the boundaries of science classrooms, pertaining only to the fact that technology, engineering and arts are nowadays acknowledged partners of science and mathematics in the landscape of STEAM. However, the relation between these activities and science education, and especially informal science learning, is far deeper and very essential. Through computational thinking, design thinking, problem-setting and solving, using their curiosity, imagination, creativity, critical thinking and knowledge to understand and change the world, young coders and makers are at the same time deeply engaged science learners gaining insights into systems, data and information, exploring patterns, getting involved in inquiry, collaborating and communicating, understanding the role of science and technology in today's and tomorrow's societies and world.

2.1.4.4 Formality and types of science learning spaces

While the COMnPLAY SCIENCE project uses the overarching term 'informal science learning' (ISL) for ease of reference, it does observe the stricter distinction between non-formal and informal science learning, and looks into both of these types of learning spaces juxtaposing them with formal science education.

According to the established definitions of these terms in the European context (CEDEFOP, 2009), formal learning occurs in an organised and structured environment (e.g. in an education or training institution or on the job) and is explicitly designated as learning (in terms of objectives, time or resources). Formal learning is also intentional from the learner's point of view, and typically leads to validation and certification. This in the world of science education largely coincides with the science classes in schools and tertiary education.

The COMnPLAY SCIENCE project turns the focus away from science classrooms. It is interested in:

- *Non-formal science learning:* that is learning embedded in planned activities not always explicitly designated as learning (in terms of learning objectives, learning time or learning support), but which contain an important learning element; non-formal science learning is intentional from the learner's point of view, and can take place in museums, science camps/clubs, etc;
- *Informal science learning:* that is learning resulting from daily activities related to work, family or leisure, which is not organised or structured in terms of objectives, time or learning support, and is mostly unintentional from the learner's perspective.

What is more, the practices focused upon cover a broad spectrum in terms of the intentionality of the science learning achieved through them, including:

- *Intentional informal science learning:* learning happening in the context of coding, making, and play activities intentionally organized to achieve aims overtly related to science learning; and
- *Unintentional informal science learning:* science learning occurring as a by-product of youngsters' coding, making, and play activities that are not intentionally meant as science learning activities.

TYPES OF LEARNING SPACES

In this landscape of non-formal and informal science learning, the project is seeking to investigate a variety of cases of science learning taking place in different spaces, including:

- Traditional established informal science learning spaces (e.g. science museums, science centres, outreach centres, libraries, zoos, etc.)
- Innovative established informal learning spaces (organized contexts such as clubs, labs, fairs, contests, etc.)
- Everyday-life informal learning spaces (e.g. personal hobbies and projects, gaming, etc).

In addition, the project does not exclude from its remit those learning spaces which although linked to school or university formal education can clearly be characterised as spaces for learning activities out of the classroom or out of the formal science curriculum.

2.1.4.5 Participant age range

The practices focused upon by the COMnPLAY SCIENCE project can address young people in various age groups, from children in the early years of education to young adults in tertiary education or in work.

In order to achieve a realistic approach within the given frame of resources, the project in principle intends to focus mainly on teenagers covering a broad spectrum from 11 to 19 years of age, thus including older children, adolescents and young adults, without nevertheless excluding activities with younger or older participants which may present particular interest.

2.2 Relevant science learning concepts

2.2.1 Science capital: a powerful conceptual and methodological approach

The concept of 'science capital'[1] is a powerful tool for the interpretation of informal science learning (Archer, Dawson, DeWitt, Seakins, & Wong, 2015) (Seakins & King, 2016). It

1 A concise introduction to science capital can be found in this animation: https://www.youtube.com/watch?v=A0t70bwPD6Y

provides policy makers and practitioners with a useful framework to help understand what shapes young people's engagement and potential resistance with science, and their participation and learning in both formal and informal science learning spaces. It has been the focus of the Enterprising Science project in the UK, a partnership between King's College London, the Science Museum and BP since 2012. The COMnPLAY SCIENCE consortium is fortunate to include both King's College London (KCL), a renowned academic institution with expertise in conceptual theorization on science capital[2], and the Science Museum (SMG), a prestigious informal science space committed to using the lens of science capital contributing insights focused on the practical application of the concept in informal learning practices.

Science capital can be visualised as a 'holdall' or 'bag' that contains all the science-related knowledge, attitudes, experiences and resources acquired throughout one's life. Science capital is what you know about science, how you think and your attitudes towards science, what you do, and who you know. Your bag is dynamic and not fixed – you can add and build science capital as you go through life.

The concept of science capital draws from the work of French sociologist Pierre Bourdieu, in particular his studies focusing on the reproduction of social inequalities in society (Bourdieu, 1984). Bourdieu coined the notion of capital – the social, cultural and symbolic resources that individuals variously possess which allow one to 'get on' in life. Science capital is a form of capital that combines all the science-related social and cultural resources and can be used as the lens through which to understand how individuals' participation and engagement in different making, coding and play activities may vary.

Building on a large body of data into students' aspirations and attitudes to science, empirical work (cf. KCL's ASPIRES longitudinal research project) has identified that students with families who had more science-related resources and experiences (science capital) were more likely to have positive aspirations around science. The Enterprising Science project further explored this relationship, developing and testing the concept of science capital, collating data on how science capital might be distributed, and investigating which interventions in and out of school might support the building of science capital, and thus increase science aspirations.

The concept of science capital helps us explain why some young people are more likely than others to participate in science, and see who might view science as important to their life and look for opportunities to learn, talk and interact with it. It can also help us to think creatively and effectively about what we might do to improve people's engagement with science. The concept encapsulates the various influences that a young person's life experiences can have on their science identity and participation in science-related activities.

[2] The science capital concept was developed as part of the Enterprising Science project based at KCL. Several members of that team have now moved to UCL alongside Professor Louise Archer, the progenitor of science capital. KCL is represented in the project through Heather King, Deputy Director of Enterprising Science, who remains based at KCL.

It should be made clear that science capital is not the same as science literacy. Beyond science literacy (science knowledge, skills and appreciation of science), which is an important part of science capital, science capital also includes practices such as what science-related things you do, who you know, and what your family values. The concept of science capital reminds us to consider the varied influences affecting a young person's participation (or not) in science. A science capital approach is about starting from personal, lived, experiences of learners and building upwards, gradually linking such experiences to canonical science. Clearly, science capital derives, in a large part, from the conversations, activities and experiences that happen outside of the classroom. In other words, informal science learning spaces can play a significant role in shaping science capital.

The COMnPLAY SCIENCE project investigates the relation of informal science learning gained through coding, making and play activities to different dimensions of science capital as defined by relevant state-of-the-art research, i.e.: scientific literacy; science-related attitudes, values and dispositions; knowledge about the transferability of science; science media consumption; participation in out-of-school science learning contexts; family science skills, knowledge and qualifications; knowing people in science-related roles; and talking about science in everyday life.

In particular, the project examines the extent to which, and specific ways in which various aspects of a young person's science capital (what they know about science, how they think and their attitudes towards science, what they do, and who they know) can actually be enriched through their engagement in different making, coding, and play activities. The lens of science capital also affords an insight into the ways in which engagement varies between individuals.

In addition, the concept of science capital helps the project carefully approach, and sheds light on, areas of tension between the fun, unconventional, often impulsive, and overall informal element of science learning occurring through coding, making and play activities outside classrooms on the one hand, and the inherent formality linked to concepts such as 'failure', assessment and accreditation, as well as the tensions between such formal learning concepts and informal sector science learning research. In face of these tensions, the project opts for a research approach that uses the conceptual device of science capital to determine where efforts may best be focused, and help understand the field of informal coding, making and play practices and how welcoming it is to various audiences.

In the discourse on the 'failing' science classroom, the project particularly distinguishes between failure to engage students and failure to help students pass exams. The proposition of the project is to look at the field of the classroom and aim to understand how one can draw on aspects of the informal science learning practices investigated in order to change this field and thus allow more students from more diverse backgrounds to 'get on' by having their capital realised. In addition, instead of attempting to 'formalise' or accredit the context of coding, making and play activities, the project investigates the extent to which the science capital accrued through such informal learning activities is in a form that may firstly be recognised in the context of formal science education and thereafter successfully translated, for instance, into the knowledge and dispositions needed for passing exams. Similarly, the project investigates the extent and ways in which, the science capital gained in the informal context of coding, making and play activities can be used in other informal science learning contexts such as those typically realized in spaces such as science museums and science centres.

Overall, the project utilizes the value and potential of science capital concepts and associated research instruments to understand why it is that some young people are able to engage in classroom science and others feel less able, and how this is related to, and can be addressed through, informal learning practices involving making, coding and play activities. In addition, the focus of the project on the concept of science capital offers practitioners a way of understanding their audiences and potentially supporting them in ways that will allow them to better ‘exchange’ the capital they have with the capital required in more formal science learning settings.

From a methodological perspective, however, it is important to note that science capital concepts and associated research instruments cannot and will not be used by the project directly for purposes of assessing or accrediting informal science learning experiences, and the science capital of individuals is not going to be scored and compared. Rather, the concept will be used to explain and interpret varied levels of participation and engagement and to identify the direction that initiatives could take to help build greater science capital in audiences / users.

Finally, while the adopted conceptual and methodological constructs borrowed from science capital research provide powerful tools for an in-depth investigation, they constitute a means and not an end for the project, which is sharply focused on carrying out research on the nature and impact of the coding, making and play-based informal science learning practices.

2.2.2 Focus on science education

The main focus of the research is on the investigation of the nature and impact of the informal science learning that may occur through coding, making and playful activities, and on the interplay of this less typical informal science learning with the more conventional, ‘mainstream’ informal and formal science education as represented in the contemporary discourses on Science, Technology, Engineering, (Arts) and Mathematics Education (STEM/STEAM).

A particularly important contribution of the COMnPLAY SCIENCE project will be the identification and in-depth investigation of the links that may exist between coding, making, and play activities, on the one hand, and on science education (STEM/STEAM), on the other hand. Such links may be intentional, i.e. representing an intended relation of certain coding/making/play activities with science (or technology, engineering, maths) learning, or unintentional but still valuable for science education, i.e. where science learning may be found to be a by-product of coding/making/play activities which not linked to science learning by design.

Thus, the research on the nature of this kind of informal science learning will investigate the conceptual and procedural relations, and complementarity within the ecology of science learning, among: a) coding, making, and play activities; b) formal science education; and c) other out-of-school science learning opportunities (cf. section 2.1.1 further above). Further, the research on the existing and potential impact of the informal science learning gained through coding, making, and play activities will look into: a) the effects that this kind of informal science learning may have on formal science education as well as on more traditional informal science learning interventions; and b) the contribution of this kind of informal science learning towards scientific citizenship (cf. section 2.1.2).

2.2.2.1 Complementary learning concepts

Within the above scope, the research on the links and contributions of coding, making, and play-based creative learning activities to science education and informal science learning also touches upon several other concepts from the landscape of contemporary research on learning and education. Thus, the investigation of the relation between these activities and science education will consider bordering areas such as:

- project-based and problem-based collaborative learning addressing real-life challenges
- design thinking, computational thinking
- learner's curiosity, exploration, imagination, creativity, creative and critical thinking
- learner's engagement and personal investment in learning
- joy, fun, playfulness vs. 'serious' learning activities

Regarding playfulness, in particular, as this is an important constituent of the COMnPLAY SCIENCE approach to informal science learning, special attention is paid by the consortium on the meaning and connotations attached to the concept of 'fun'. It is acknowledged that such meaning may differ considerably in the various country and cultural contexts. Thus, to achieve consistency and validity in the investigation of playfulness and fun, the consortium will pay attention to aspects such as the nature and origin of fun (e.g. from learning, playing, adventure/thrills, sound, light, social contacts, etc), as well as who is to assess the importance and value of such fun (e.g. activity participants, activity facilitators, educators, parents, etc).

2.2.3 European landscape of science education for responsible citizenship

A strong characteristic of the COMnPLAY SCIENCE project is its emphasis on positioning informal science learning through coding, making and play activities, in the contemporary overarching science education discourse at the European level.

The project is inspired by, and in multiple ways responds to, the call for science education for responsible citizenship, a 21st century vision for science for society within the broader European agenda offered by the Expert Group on Science Education in 2015 (European Commission, 2015).

This conceptual context of the project is presented in the following paragraphs in summary.

2.2.3.1 Science with and for society, addressing societal challenges

Europe's aspirations and global challenges: Promoting smart, sustainable and inclusive growth, finding pathways to create new jobs and offering a sense of direction to our societies, are the ambitious goals that the European Union has set (European Commission, 2010). This requires significant strengthening of our knowledge and innovation capacity and our creative capability as drivers for future growth (European Commission, 2010). At the same time, in an increasingly inter-connected and globally competitive world, in which research and technological know-how expands, new economic opportunities often come hand in hand with complex societal challenges.

Society's engagement in research and innovation: Europe chooses to address these challenges through the engagement of society in research and innovation processes, so that research and innovation are aligned to the values, needs and expectations of society. This is the heart of Europe's flagship concept of Responsible Research and Innovation.

Inclusive and informed decisions: We need to provide the space for open, inclusive and informed discussions on the research and technology decisions that will impact citizens' lives. In this, science plays a most crucial role, by informing citizens and politicians in an objective, trustworthy and accessible way and thus allowing the society to make decisions together rather than from polarised positions and to take responsibility for those decisions, based on sound scientific evidence.

Need for a different workforce: Today's society needs to provide the workforce for future markets and innovative industries in Europe. Already today, it is evident that global competition and technological developments are transforming the economy and the labour market while also opening personal, professional and business opportunities for all citizens, enterprise and industry. Children entering school now are likely to change careers two or three times over their lifetimes (Tsai, 2014). As these developments quicken pace, there is much greater appreciation of the necessity to involve the entire pool of human resources and talent.

Shortfall in science-knowledgeable people in a science-thirsty society: Europe faces a shortfall in science-knowledgeable people at all levels of society and the economy. Despite the increase in the numbers of students leaving formal education with science qualifications in the last decades, there has not been a parallel rise in the numbers interested in pursuing science related careers nor have we witnessed enhanced science-based innovation or any increase in entrepreneurship (Sjøberg & Schreiner, 2010). Nevertheless, society is thirsty for science. Evidence shows that European citizens, young and old, appreciate the importance of science and want to be more informed and that citizens want more science education (European Commission, 2013). Over 40 % believe science and technological innovation can have a positive impact on the environment, health and medical care and basic infrastructure in the future (European Commission, 2014).

The crucial role of science education today: On this background, our societies need to educate smart, creative and entrepreneurial individuals with the confidence and capability to think autonomously and critically, engage in lifelong learning, the ability to generate new knowledge, social and technological innovation and utilize and adapt to technological change, as well as the desire, engagement and capabilities for active citizenship, from an early age. In particular, science education’s appropriate response is direly needed. Science education, as a field of practice, research and innovation, needs to become more responsive to these needs and ambitions of citizens and society, and reflect their values. A more responsive science education can promote broader participation in knowledge-based innovation that meets the highest ethical standards and helps ensure sustainable societies into the future. It is the unique vehicle that can assure that Europe will meet its goals, by equipping citizens, enterprise and industry in Europe with the skills and competences needed to provide sustainable and competitive solutions to the arising challenges (Science Europe, 2013). Europe’s expectations from science education can be summarized as follows:

- To help all citizens acquire the necessary knowledge of and about science to participate actively and responsibly in, with and for society, successfully throughout their lives.
- To support people of all ages and talents in developing positive attitudes to science.
- To nurture children’s curiosity and cognitive resources, so as to equip future researchers and citizens with the necessary knowledge, motivation and sense of societal responsibility to participate actively in the innovation process.

2.2.3.2 The Framework for Science Education for Responsible Citizenship

In this landscape, the 2015 expert group report (European Commission, 2015) proposes a ‘Framework for Science Education for Responsible Citizenship’ consisting of six key objectives and associated recommendations, which in combination, can help bring about the systemic changes required in science education to generate a sustainable effect in communities and across society. The key objectives are presented here in overview:

- Science education should be an essential component of a learning continuum for all, from pre-school to active engaged citizenship.
- Science education should focus on competences with an emphasis on learning through science and shifting from STEM to STEAM by linking science with other subjects and disciplines.
- The quality of teaching, teacher induction, pre-service preparation and in-service professional development should be enhanced to improve the depth and quality of learning outcomes.
- Collaboration between formal, non-formal and informal educational providers, enterprise, industry and civil society should be enhanced to ensure relevant and meaningful engagement of all societal actors with science and increase uptake of science studies and science-based careers and employability and competitiveness.
- Greater attention should be given to promoting Responsible Research and Innovation and enhancing public understanding of scientific findings and the capabilities to discuss their benefits and consequences.
- Emphasis should be placed on connecting innovation and science education strategies, at local, regional, national, European and international levels, taking into account societal needs and global developments.

2.2.4 Taking stock of other research

Next to the above described science capital research and the current European discourse on science education, the conceptual foundation of the COMnPLAY SCIENCE project also takes into account the wider contemporary landscape of research into science learning.

For instance, the current ongoing discussion in the consortium on the assessment of the impact of the investigated practices in the project is informed by previous research such as the work reported in the "Framework for evaluating informal science learning practices"[3] (Friedman, ed., 2008) i.e. a National Science Foundation (NSF), USA, report.

In addition, in its efforts to define and identify 'best practices' the consortium is exploring how previous research can provide useful approaches and tools. For instance, Falk, Randol and Dierking (2011)[4] is an exploratory study that provides the project with useful insights into the field of informal science education (ISE). This study aimed to determine whether the informal science education community functions as an effective community of practice. Research questions included: How do professionals describe and self-identify their practice, including what missions, goals and motivating factors influence their professional work? What challenges do they face and how are these resolved? Is participation in ISE activities perceived as core or peripheral to their work? Open-ended interviews were conducted with high-level representatives of 17 different ISE sub-communities and results were analysed qualitatively. Findings showed this broad assortment of ISE sub-communities as not currently functioning as a cohesive community of practice. Although examples of shared practice and ways of talking were found, evidence of widespread, active relationship-building over time and coalescence around issues of common concern were absent. A current "map" of the ISE community is proposed and thoughts about how this map could alter in the future are suggested.

Falk et al (2015)[5] conducted an exploratory research to analyse the science education community in the UK. In contrast to historic research approaches that focus exclusively on single organizations and/or educational events, this study utilized specific community ecology analytical tools and approaches to describe and analyse the UK science education community as a whole. Data suggested that overall the UK science education community is highly interconnected, and collaborative within individual sectors and moderately interconnected and collaborative between sectors. Schools and to a lesser degree universities were outliers to this pattern. An important conclusion was that management to maximize the effectiveness of science education the UK science education community would

[3] www.informalscience.org/sites/default/files/Eval_Framework.pdf

[4] Falk, J H, Randol, S, and Dierking, L D (2011). Mapping the informal science education landscape: An exploratory study. Public Understanding of Science, 21, 7, pp. 865-874. https://doi.org/10.1177/0963662510393606

[5] Falk, J H, Dierking, L D, Osborne, J , Wenger, M , Dawson, E and Wong, B (2015). Analyzing Science Education in the United Kingdom: Taking a System-Wide Approach. Sci. Ed., 99: 145-173. doi:10.1002/sce.21140.

involve support for continued diversification of the number of science education entities in the system and encouragement of reciprocally collaborative, synergistic relationships.

Further, the work of the Wellcome Trust in the UK on informal science learning experiences and the potential they offer for young people to engage with and learn about science in a way that works for them, is also an important source of information on the state-of-the-art and inspiration[6]. In 2014, the Wellcome Trust launched the Science Learning+ initiative in partnership with the National Science Foundation and the Economic and Social Research Council, aiming to explore the impact of informal science learning and encourage science engagement practitioners and researchers to collaborate. In addition, they conduct work aiming to help give young people from disadvantaged backgrounds more opportunities to engage with and take part in science activities outside of school, as well as having established the National Forum for Public Engagement in STEM, aiming to help key funders and organisations involved in public engagement in science to work together strategically. Overall, the Wellcome Trust's Review of Informal Science Learning[7] provides useful input for the project. It is worth noticing that the Wellcome Trust conducted a range of studies on mapping the ISL sector in the UK, using a mixture of online surveys and interviews. One of the aspects highlighted is the sheer breadth of activities and approaches even a single practitioner can be conducting at a given time.

2.2.5 Equity and risks of disadvantage and exclusion

In all aspects of the research, issues of equity are recognised as extremely important. The COMnPLAY SCIENCE consortium is knowledgeable about, and sensitive towards, such factors as documented in the contemporary science learning discourse.

Gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion will systematically be taken into account, informing all research foci of the project. This may include:

- analysing the investigated coding, making, and play-based practices in relation to issues of equity and risk of disadvantage and exclusion;
- characterizing the practices in terms of the threshold they represent to different groups;
- appreciating the extent to which the practices accentuate socio-economic differences, e.g. as children of well-off and educated families are more likely to engage in them,
- identifying opportunities and best practices for mitigating such effects;
- studying ways in which relevant good practice can feasibly be transferred across cultural borders in Europe.

In addition, the project will places particular attention on actively promoting identified best practices which successfully address issues of equity and combat risks of disadvantage and exclusion.

[6] https://wellcome.ac.uk/what-we-do/our-work/increasing-informal-science-learning
[7] https://wellcome.ac.uk/sites/default/files/review-of-informal-science-learning.zip

2.3 The research questions

On this background, the concepts and aspects investigated by the project in the three areas (the nature of informal science learning, the impact of informal science learning on science education, and the impact of informal science learning on scientific citizenship and the society) are listed below in the form of general research questions.

2.3.1 Nature of informal science learning

How does what we already know about learning through coding, making, and play activities, conceptually and procedurally map with our current understanding of informal science learning in the wider context of science education?

- How can this be analysed across the dimensions of science capital, i.e. the knowledge, attitudes, experiences and resources ('what I know about science', 'how I think and my attitudes towards science', 'what I do', and 'who I know') gained?
- Typically, in the formal world of science education, the focus falls mainly on knowledge, while science-related attitudes, experiences and resources are mainly supported by out-of-school learning opportunities, families and communities. How does this shape in the field of coding, making and play-based activities?
- How does informal science learning gained through coding, making and play activities map with our understanding and knowledge of how issues of equity relating to gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion feature in science education and affect a young person's science capital?

Does empirical evidence gathered by the project show that various aspects of a young person's science capital can be enriched through their engagement in different making, coding, and play activities?

- To what extent and in which ways can this happen?
- What are the factors affecting the recognition and subsequent growth of science capital in different contexts, for example, in an individual's science capital?
- How is this effect shaped by the context? For example: Are there observed differences in science capital gains between activities taking place in organized contexts and completely informal activity in everyday life? Are there observed differences in science capital gains between activities which, from their conception, intend to achieve informal science learning outside the classroom, and activities which are not originally intended towards science learning at all?
- How do observed gains relate to issues of equity linked to gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion?

More generally, according to the evidence gathered, to what extent and how can and do coding, making and play-based informal science learning practices:

- adopt and adapt an inquiry approach to science learning?
- foster individual reflection and empowerment in science learning?
- support the acquisition of knowledge of and about science, the development of positive attitudes to science
- nurture children's curiosity and cognitive resources so as to equip them as future researchers and citizens with the necessary knowledge, motivation and sense of societal responsibility to participate actively in the innovation process?

2.3.2 Impact of informal science learning on science education

What observed and potential effects does informal science learning gained through coding, making, and play activities have on formal science education?

Are tensions observed between them? Which?

What are the synergies, or opportunities for synergies, between them and their complementary roles?

- To what extent do coding, making and play-based informal science learning practices contribute to the societal objective of ensuring a science education for all?
- How do they complement the breadth and depth of knowledge about science pursued in formal science education?
- How can and do they contribute to learning through science and shifting from STEM to STEAM by linking science with other subjects and disciplines? How do they contribute to learning about science through other disciplines and learning about other disciplines through science?
- How can and do they contribute to science education being a means of acquiring key competences to ease the transition from education to employability?
- How do they strengthen connections and synergies between science, creativity, entrepreneurship and innovation? To what extent and how can and do they encourage open schooling, turning schools, in cooperation with other stakeholders, into agents of community well-being, with families as real partners in school life and activities, and with professionals from enterprise, civil and wider society actively involved in bringing real-life projects into the classroom?
- To what extent can such activities succeed for individuals for whom the formal classroom experience has not led to the building of further science capital? (Note that the classroom can be very effective in building science capital for those that also have access to other experiences, such as science-related talk at home, science influences in the family, etc. For other individuals, the classroom experience can be unwelcoming and alienating, and this may be compounded if they have few other 'science-related' experiences at home.)

To what extent may it be possible to introduce assessment and accreditation in this informal science learning field? What are the barriers, dangers and potential losses in attempts to 'formalise' such informal science learning practices?

How do the observed and potential effects on science education relate to the array of issues of equity linked to gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion from science education? To what extent and how can and do coding, making and play-based informal science learning practices help widen access, and provide more young people with opportunities to pursue excellence in science learning and learning outcomes?

What observed and potential effects does informal science learning gained through coding, making, and play activities have on more traditional informal science learning spaces and interventions, e.g. those of science museums and centres?

- Are tensions observed between them? Which?
- What are the synergies, or opportunities for synergies, between them and their complementary roles, as well as among them and formal science education?
- How do the observed and potential effects on traditional informal science learning relate to issues of equity linked to gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion? To what extent and how can and do coding, making and play-based informal science learning practices address socio-economic, gender and cultural inequalities in the context of 'traditional' informal science education, widening access, and providing more young people with learning opportunities?

How do coding, making and play-based informal science learning practices shape the needs for quality teaching, teacher induction, pre-service preparation and in-service professional development in science education?

2.3.3 Impact of informal science learning on scientific citizenship and society

To what extent can and how does informal science learning through coding, making and play activities contribute towards scientific citizenship?

To what extent can and how do coding, making and play-based informal science learning practices contribute to the objective of science education being an essential component of a learning continuum for all from pre-school to active engaged citizenship?

How can and do they contribute to ensuring that young people and adult learners are both motivated to learn and equipped to fully engage in scientific discussions and decisions?

What attitudes, values and dispositions do young people as learners and citizens develop through such activities, towards science, scientists, and science-related information in everyday life?

What potential do such activities have for encouraging the development of more scientifically informed behaviours and decisions by young people as consumers and citizens?

What potential do such activities have for encouraging young people's engagement in science with and for society, e.g. through their involvement in citizen science or through their own initiatives linking science to societal needs and concerns?

To what extent can and how does informal science learning through coding, making and play activities promote partnerships between learners, their facilitators, researchers, innovators, professionals in enterprise and other stakeholders in science-related fields, with them working on real-life challenges and innovations and considering associated ethical and social and economic issues?

To what extent and how can such activities contribute to the collaboration between formal, non-formal and informal educational providers, enterprise, industry and civil society to ensure relevant and meaningful engagement of all societal actors with science, eventually increasing uptake of science studies and science-based careers and employability and competitiveness?

To what extent and how can such activities contribute to promoting Responsible Research and Innovation, enhancing public understanding of scientific findings and the capabilities to discuss their benefits and consequences, and more generally embedding social, economic and ethical principles into science learning in order to prepare students for active citizenship and employability?

How can and do coding, making and play-based informal science learning practices contribute to ensuring that all citizens are equipped with the skills and competences needed in the digitalized world?

How does the observed and envisioned impact on scientific citizenship and society relate to issues of equity linked to gender, ethnicity, class, other cultural, socioeconomic and geographical differences and relevant risks of disadvantage and exclusion?

Last but not least, how can we make sure that the new knowledge generated by this project on the nature and impact of informal science learning will enable European societies and economies to develop innovative coding, making, and play related initiatives, products and services, with a stronger science learning effect and a clear link to RRI concerns and societal needs, readily available to meaningfully and purposefully enrich and innovate formal science education and traditional informal science learning interventions?

3. Methodological Framework

Based on the above described Conceptual Framework, the Methodological Framework becomes more practical, providing the general description of the methodological approach of the project, reflecting the overall conception of the research as well as the realities and practicalities of the field as they have been recorded up to the time of delivery of the present report. Thus, the Methodological Framework operationalises the Conceptual Framework into a high-level methodological design for the realisation of the activities that will take place in the subsequent project phases.

The methodological design presented in this section will be refined in November 2018 – January 2019 (M6-M8) and the corresponding methodological research instruments and tools will be developed, leading eventually to deliverable D1.2 'Research Instruments and Tools', which will provide relevant concluding decisions. After that point, the consortium may be revisiting aspects of the methodology when and as required, so as to adjust the research to the emerging realities on the field.

Thus, the provisions of the high-level methodological design presented in this section will become more concrete in Deliverable D1.2, through further refinement and mainly through the tools that will materialise and enact this design.

A priority of the Methodological Framework is to link the general assumptions and intentions of the project with the very diverse realities of the informal science learning practices that the project intends to investigate on the field. To this end, using the Template for the Identification of the Consortium's Own Practices included in Annex A of this report, the consortium has identified and gathered the first descriptions of practices that the consortium considers as very relevant to the research and to which consortium partners may have immediate or relatively easy access for the purposes of the empirical research. These first identified practices, referred to as "the consortium's own practices", are presented in section 3.1.5 further below.

3.1 Methodological design

COMnPLAY SCIENCE is designed as an interdisciplinary research project with a strong element of engagement with stakeholders and a focus on maximizing the impact and the exploitation of the outcomes of the research conducted. The overall duration of the project is 36 months (June 2018 – May 2021).

The methodology of the project consists of three major steps: a) Preparation; b) Empirical Research; and c) Follow-up. The core phase of Empirical Research takes up the greatest part of the project, lasting 19 months (M9-M27). It is preceded by the 8-month-long phase of Preparation (M1-M8), and followed by the remaining 9 months of the Follow-up phase (M28-M36), which concludes the project.

3.1.1 Research scope and needs

The methodology of the project includes the methods and tools required for:

- The identification, pooling, and selection of practices, as well their enhanced presentation through the online inventory and publicizing through social media (WP2, and partially WP4).
- The in-depth participatory research on the nature and impact of coding/making/play-based informal science learning (WP3), in two major stages:
    - nine-month exploratory stage (M9-M17, February-October 2019), exploration of the nature of learning

  - ten-month insight stage (M18-M27, November 2019-August 2020), deeper probing into the nature of learning, investigation of the impact of learning
- The transformation of the findings of the research into inspiration and guidance for practitioners, and recommendations for policy development and further research (WP4).

3.1.1.1 Identification, pooling, selection, presentation of practices

In relation to first point above, namely the identification, pooling, selection, and presentation of practices, detailed methodological decisions will be reported in deliverables D2.1 'COMnPLAY SCIENCE Identified Practices and Research Sample', D2.2 'COMnPLAY SCIENCE Online Inventory of Practices – First Version', and D2.3 'COMnPLAY SCIENCE Online Inventory of Practices – Final Version'. Considerations of the use of quantitative and qualitative methods discussed in section 3.1.2 further below also pertain to this aspect of the research. The relevant processes are summarised in the following paragraphs.

Early on in the project, work is conducted for the identification and pooling of practices (Task 2.1, M4-M8). As a first step, the consortium identifies several and diverse existing coding, making and play-based practices taking place outside formal science classrooms which, in the light of the conceptual framework developed, appear to bear some promise for informal science learning. The aim is a comprehensive coverage of the field allowing the project to look at a wide range of loci and modes of coding, making, and play activities, with diverse characteristics as to their promised science learning potential in relation to a variety of dimensions of STEM/STEAM learning, RRI, and science capital. To this end, the consortium:

- draws on its own activities and background to contribute diverse practices as components for the case studies that will be defined for the purposes of the research (cf. discussion on the definition of the case studies in section 3.1.5 further below); and
- actively seeks to enrich this initial list with additional practices, by identifying, inviting and motivating other practitioners to contribute their practices to the project.

As a next step, the project analyses the various practices contributed and pooled, and identifies and presents at least thirty major practices. These 30 major practices are mutually distinguishable cases of practice, each one with its own characteristics, and all of them together comprehensively covering all salient elements featuring in the broad field investigated by the project, exemplifying the various options available and opportunities and challenges arising.

From the identification of practices at the early stages up to the end of the project (Task 2.3, M4-M36), the consortium works to make the at least 30 major practices available to stakeholders and the public so that they can be further disseminated and exploited in the wider world of science learning. To this end, the project develops an online inventory which offers the identified practices appropriately categorized and annotated in the light of the findings of the research, including extensive case studies of those practices which have been investigated in depth. Particular attention is placed on promoting best practices successfully addressing issues of equity by combatting risks of disadvantage and exclusion (e.g. linked to gender, ethnicity, class, other cultural, socioeconomic and geographical differences across

Europe), providing also suggestions about the feasibility of transferring such practices across cultural borders.

The main part of the work for the analysis, organization and annotation of the practices falls in the second, main phase of the project, i.e. Empirical Research. The foundations for this are laid through the conceptual, methodological and sampling work carried out in the Preparation phase.

The online inventory of practices is delivered as a distinctive section of the project website, accompanied by a usage manual and explanatory report, in two stages: as a first version in M17 (D2.2), reflecting the interim findings from the research on learning, and in its final form at the end of the project (M36), with the analysis, organisation and annotation of the practices now reflecting all knowledge generated through the project. The inventory is actively publicised through social media, and is disseminated systematically to stakeholder communities across Europe. A moderate target set is that this section of the website will receive at least 1,000 unique visits in the course of the project.

3.1.1.2 Inspiration, guidance, recommendations

Respectively, in relation to the transformation of the findings of the research into inspiration, guidance and recommendations for practitioners, researchers and policy makers, methodological details will be included in deliverables D4.1 'Communication, Dissemination and Exploitation Strategy and Plan' and D4.2 'Community Building Methods and Tools'.

In summary, it is noted here that the project adopts an overall outward-looking, community-centred approach foregrounding continuous engagement with stakeholders so as to facilitate efficient realization of the research and achieve and maximize the expected impact. In parallel to the present report, in M5 the project is also delivering its communication, dissemination and exploitation plan (D4.1), on the basis of which the consortium continually monitors the effectiveness of these efforts and adjusts them to the arising circumstances so as to maximize the impact of the project in the short, medium and long term.

Community building is integral to the efforts of the project. The continuous involvement of stakeholders and especially of learners and their educators/facilitators in the research process is required for the project to carry out its in-depth research and achieve the expected impact. Thus, efforts for the building of a community of stakeholders around the project also start from the outset. Plans are made and tools are developed so that the consortium can collaborate with learners and their facilitators, other relevant practitioners, and policy makers from all participating countries and beyond, during the whole project. Facilitating their consultation and involvement in all stages of the participatory research, the research can look into real life conditions and applications of coding, making and play for informal science learning, and the community can guide the consortium towards delivering outcomes ready for full and immediate exploitation across Europe. A special set of community building methods and tools were delivered in M3 (D4.2) to facilitate not only the consortium in the next steps of the project, but also the interested stakeholder who may wish to get involved in community building linked to the project, e.g. for the creation of a special interest group within the community.

Overall, the community created in the Preparation phase and maintained in the subsequent phases will consist of at least 500 individuals who will be available for participation in broad-base quantitative aspects of the research (the wider community), and among them at least 100 individuals available for participation in the in-depth qualitative aspects of the research (the core community). Throughout the project, the composition of the community is monitored and moderated so that the stakeholders involved comprehensively cover all aspects of the project and of its expected impact. Interaction, exchange and sharing within the community is also actively monitored, facilitated and motivated, exploiting social media, other digital spaces and tools, as well as the gameful design of the research described further below (cf. section 3.1.3).

An integral part of the communication, dissemination and exploitation strategy is the organization of several public events directly engaging stakeholders and especially learners, their facilitators, and policy makers. At least 50 communication, dissemination and exploitation activities, including several local events and at least 9 major events, are realised in the course of the project, addressing at least 2,000 individuals in total.

The at least nine major events are organized in conjunction with corresponding major project consortium meetings in the countries of the consortium so that all project partners can contribute to these public communication events without additional travel and subsistence costs to the project. The nine major events will be attended in person by at least 500 participants, while the project will also offer the option of following the proceedings at a distance, through video streaming and the popular social media. Four of the nine major events constitute the foreseen major training events which will be attended by at least 300 participants in total. These are the Grand Launch Event and Winter School (M9), the First Research and Innovation Workshop and Autumn School (M17), the Second Research and Innovation Workshop and Summer School (M27), and the Final Conference and Fair (M36). Therefore, each of the nine major events is expected to be attended by 40-80 participants, with approximately 80 participants in each of the major training events. The full list of the nine major events with indicative descriptions of their purpose is the following:

Introductory Workshop (M1): introduction to the aims and methods of the project, invitation to stakeholder communities to collaborate

Community Workshop (M5): presentation of the conceptual framework of the project, promotion of the call for the engagement of communities and practices with the research

Grand Launch Event and Winter School (M9): presentation of the research methods and tools, of the identified and pooled practices and of the research sample; playful start of the engagement of the communities in the research

Community Workshop and Contest Launch (M13): presentation of first experiences from the research on learning, motivation of the communities engaged in the research through the launch of the first contest

First Research and Innovation Workshop and Autumn School (M17): presentation of the interim findings of the research on learning and of the first version of the online inventory, finals and conclusion of the first contest

Community Workshop and Contest Launch (M22): presentation of experiences from the research on learning and impact, motivation of the communities engaged in the research through the launch of the second contest

Second Research and Innovation Workshop and Summer School (M27): presentation of the findings of the research on learning and impact, finals and conclusion of the second contest, launch of the third contest

Key Stakeholder Workshop (M32): communication of all project findings and of the pre-final plans for further exploitation to key stakeholders and policy makers

Final Conference and Fair (M36): presentation of all project outcomes to a wide audience of practitioners, other stakeholders and policy makers, finals and conclusion of the third contest.

Finally, the communication, dissemination and exploitation efforts that have been in place since the start of the project are intensified after the completion of the empirical research, during the Follow-up phase (M28-M36) concluding the project. Then, the consortium finally delivers all findings and outcomes of the project in a comprehensive set of concluding communication events and publications, which present the project outcomes appropriately to the various stakeholder and policy making communities.

3.1.1.3 Empirical research

The central and most crucial part of the methodology of the project refers to the methods that will be used in the empirical research, i.e. in the two stages of the in-depth research on the nature and impact of coding, making, and play-based informal science learning (WP3) in the period between M9 (February 2019) and M27 (2020). Overall in this period of 19 months of intensive interdisciplinary field research involving implementation of several activities in the context of at least 10 case studies (cf. section 3.1.5 further below), data gathering from the field, and data analysis, the consortium devotes approximately half of the overall project effort.

More precisely, the empirical research is conducted in two major stages: the first, nine-month exploratory stage (M9-M17), and the second, ten-month insight stage (M18-M27).

The exploratory stage includes the first part of the research on the nature of the informal science learning gained through coding, making and play practices, aiming to map the field in detail, provide first evidence-based indications, and prepare the field for the subsequent insight stage. The findings and outcomes of the exploratory stage are presented in M17 in an interim research report on learning (D3.1).

The insight stage focuses on the corroboration of the findings from the exploratory stage on the research on the nature of the informal science learning, and their enrichment through deeper insights gained by means of special focus studies. In parallel, in the insight stage the project uses the interim findings from the exploratory stage to look deep into the impact of the informal science learning gained through coding, making and play activities on science education and the society. The final outcomes of the insight stage, which also concludes the whole empirical research, are delivered in M27 in the final research reports on learning, impact on science education, and impact on society (D3.2, D3.3).

The empirical research conducted is of a strongly participatory, practice-centred nature, engaging learners and their facilitators in rich interaction with the project in the context of real-life practice. Using the research tools developed, the consortium systematically surveys, observes, consults with, and gamefully engages participants of various activities in intensive self-reflective research.

Each of the at least ten case studies of selected practices is formed as a self-contained local research project, which through intensive analysis of empirical evidence collected from the field of practice sheds light on the questions on the nature and impact of informal science learning investigated by the project.

Building on the advantage of comprehensiveness gained through the unifying and balancing effects of the careful conceptual, methodological and sampling work in the Preparation phase, research on the field is organised and conducted in a more decentralized manner so as to adjust to the local circumstances and make best use of the availability and potential of each implementation context and each selected practice.

Nevertheless, all case studies are continually monitored and coordinated centrally, through the procedures of WP and Task management, to secure full achievement of the research objectives, with adjustments and corrective interventions made when and where necessary. Each project partner functions as coordinator and facilitator of at least one case study, with priority given to them acting as local coordinators and facilitators in their country context.

Overall, the engagement of stakeholders in the participatory research is facilitated by the strong community-centred aspect of the project and the realization of the major events and training activities, with the participation of stakeholders and especially learners and their facilitators (cf. section 3.1.1.2 above).

The final methodological decisions and details regarding this core aspect of the project will constitute the main part of deliverable D1.2 'COMnPLAY SCIENCE Research Instruments and Tools'. Relevant dimensions of the high-level methodological design are presented in the following sections of the present report.

3.1.2 Mixed-methods research

In the work on practices (WP2; cf. section 3.1.1.1 further above) and in the empirical research (WP3; cf. section 3.1.1.3 above), the project draws on both traditions of quantitative and qualitative research, aiming to cover the field both in breadth and in depth respectively.

Overall, the aim is to involve a wider community of at least 500 individuals in the larger-scale quantitative research, and a narrower core community of 100 selected informants in the focused qualitative research.

For the identification, pooling, selection, and presentation of practices, larger-scale quantitative research involves the wider community of stakeholders and especially practitioners from the field mainly in questionnaire surveys. On this basis, focused qualitative research follows involving a smaller core community of selected informants mainly in interviews.

In the two stages of the empirical research (exploratory in M9-M17; insight in M18-M27), broad quantitative research involves the wider community of stakeholders mainly in questionnaire surveys. The in-depth qualitative research involves a smaller core community of selected informants in personal interviews, focus groups discussions, observations, consultations, and/or other forms of self-reflection and participatory research.

In addition, an integral and very innovative part of this methodological approach is the gameful element of the research design, which is presented in the next section (3.1.3).

The combination of the above quantitative, qualitative and gameful approaches, and the adoption, adaptation or development of the appropriate research instruments within each of them, is shaped so as to ensure the collection of appropriately rich data from the field in order to provide insights in response to all research questions (cf. section 2.3 further above).

3.1.2.1 Some considerations on the use of quantitative and qualitative methods

The consortium is cautious with the use of quantitative methods to draw generalisable results and valid comparisons across the participating countries and practice contexts, given the many, frequently latent, variables on the field that are not within the control of the consortium, as well as the fact that understandings of several of the terms questions under discussion may vary considerably in the various contexts after translation from English. In addition, is worth noticing in previous studies on mapping the ISL sector (e.g. those of the Wellcome Trust in the UK) that the sheer breadth of activities and approaches observed on the field makes capturing this reality in a quantitative format and specific predetermined options quite problematic.

Thus, online questionnaire surveys will be used to collect basic information and some surface characteristics (e.g. the location, age range, timeframe, type(s) of activity, etc. of specific practices), followed by more detailed interviews (or other forms of qualitative research) looking deeper into the nature and impact of informal science learning practices.

More generally, questionnaire surveys and in-depth interviews are complementary to each other. Thus, for example, in the current efforts of WP2 to identify and pool practices, the discussion in the consortium is leaning towards focusing an online questionnaire survey mainly on the practices (why, what, where, when, with whom, and how), while the follow-up interviews will focus mainly on the practitioners.

Overall, data collected through questionnaire surveys will be analysed with the use of descriptive statistics and, where valid, further statistical analysis will be performed. The analysis of the quantitative survey data will be used to provide useful background to the rest of the research and in particular to the follow-up interviews aiming to provide in-depth insights.

Finally, especially in the early exploratory parts of the research, the qualitative study of the field will aim, if possible, to develop a categorical system as the foundation for further quantitative research later on in the project and beyond.

3.1.3 Gameful research design

A central innovative element of the methodological approach and of some of the research tools and instruments developed is the use of gameful design (gamification) aiming to facilitate the community's sustainable intrinsic motivation of the community for active participation in the research processes. This is achieved through a gameful design of the process of learners' and practitioners' involvement in the research, and a number of contests for learners and practitioners organized by the project.

3.1.3.1 Gameful involvement in the research

This is realized through the COM'nPlay-Science mini-game, which is designed, developed and implemented as the main tool for the promotion and support of the continuous prolonged engagement of learners and their facilitators in the 19-month-long field research. Through the utilization of appropriate gamification mechanics (e.g. collection of point and badges, leaderboards, progress trackers etc.), though mini-contests online, as well as through rich opportunities for players to share and promote their activities and achievements within the community, the game helps in the structuring and timing of the various empirical research activities in very diverse settings, and motivates players to participate in surveys, interviews, workshops, etc.

The game, offered both as a mobile app and on the web, is designed and developed by OVOS in the whole of the Preparation phase, through intensive consultation with project partners and selected informants from the community of stakeholders, following and agile development process. It becomes available as part of the suite of research tools, ready for use by learners and their facilitators in a first functional form in M8. This first version is launched in the Grand Launch Event and Winter School (M9), playfully kick-starting the engagement of the communities in the research. Subsequently, based on feedback from the use of the game in the first phase of the field research, OVOS keeps improving the game and finally delivers it in an enhanced form in M17. This final enhanced version is launched in the First Research and Innovation Workshop and Autumn School (M17) and appropriately promoted to the community to boost engagement in the research process.

CURRENT GAME CONCEPTION AND DESIGN: THE COMNPLAYER APP

At the time of delivery of the present Framework (M5), OVOS in collaboration with the consortium has already developed a concept and first design of the mini-game, the so-called ‘COMnPLAYer App’, which is presented in the following paragraphs.

The app consists of three areas: Storytelling, Quiz Gameplay and Surveys. The basic components within those are presented below.

Storytelling:

- A fictional introductory story, aiming to prepare the mood/atmosphere for the app and to frame it. OVOS has been working on two characters: an age-appropriate random robot called STEAMY (which fits in with the logo of COMnPLAY SCIENCE), and a female, cool and cynical computer scientist, who are interacting in an illustrated comic-like scenario. The text will be underneath the pictures so it can be translated into the various languages of the project. This is the basic storyline: The robot was designed by the scientist to become an “AI Life Coach” to support young people with career decisions. Its task is to ask the scientist lots of questions to learn about humans, their strategies and motives. Steamy will re-appear in other parts of the app and can be used for dissemination purposes (facebook etc). The story will be tested with young people to confirm its appeal.
- Role Models (tentative name, to be possibly replaced by something more interesting): The game will initially present one or two short biographies of people who ended up in science-related fields but not on a straightforward career path, i.e. who only discovered it by chance or after trying out various things. This is considered important in challenging stereotypes and showing teenagers that you don’t have to be super ‘sciency’ to follow a science career. The game design also foresees picture and text interviews or short videos in which these people will explain how they ended up where they are now. The text underneath can be translated into other languages. Over the course of the project more of these short biographies can be added.
- Student experiences: The game design team will speak to one or two students who have participated in a recent youth hackathon and see what their experience was like, asking carefully selected questions. They will then illustrate these short experiences in an appealing art style. Throughout the project, children and teenagers who take part in activities can send in their experiences with these activities (perhaps submitted through the project website) so that the best ones will be selected, anonymised, illustrated and uploaded to the app. This will also be linked to the survey part of the app: after having read the story, users will be able to fill in a survey about the activities they are taking part in.

Quiz Gameplay:

- “Steamy Wants to Know”: The fictional intro story provides one of the foundations of the quiz. The robot Steamy asks many questions because he wants to become an AI Life Coach and this is what is conveyed: The robot wants to know the full range of what/how people think/act/know so that he can make sense of the world and help in improving the future situation for young people regarding jobs, careers information, and the general state of the world. The fun in these kind of questions stems from the robot's misassumptions and lack of basic human knowledge. We could include quirky, "random" (no correct answer) questions that will help to pace the activity and give the users a chance to smile/relax whilst filling in other information.

- Science Fun Facts: Aiming to demystify the profession of scientists a little, and show that the range of science fields is a lot bigger than most people think. Even the really successful scientists were/are real humans. What connects them all is the motivation to know more, make the world better and discover what went wrong. Adding an age-appropriate Fun Fact Quiz about scientists could make this notion more accessible to young people. Moreover, questions can be added about science and inventions in the quiz along the lines of Trivial Pursuit (some 'wow-y' 'did you know...' sort of facts).

Surveys:

- Mood barometer: Once they have read the student experiences (see under 'Storytelling'), a survey follows in which participants can answer a few survey questions on what their point of view is. This is available for everyone using the app.
- Survey Deck: There will be survey card decks for students who are participating in research activities as part of the COMnPLAY SCIENCE project. Voucher codes can be used to unlock these specific decks for the participants. The right questions need to be asked so that we gather all information and not only the answers we want to hear. The data will be available for the research.

Finally, the following descriptions for the promotion of the COMnPLAYer App have been developed:

- Short message: 'Come on, player! Science! Download the app now to experience science in a new and fun way!'
- One-paragraph description: 'The COMnPLAYer App lays the basis for playful science learning as well as for the research of the COMnPLAY SCIENCE project. Dive into the experience by creating a hilarious scientist avatar for yourself! Now it's time to consider: What can Artificial Intelligence do for us in future? How have scientists shaped our world and what does it entail to be a scientist in 2019? Meet the quirkiest survey robot in the world and feed him your answers! The gamification elements enable you to have your say on what "science" actually means to you. Come on, player! Science!'

Feedback from partners and further design and development will follow until the delivery of the first version as part of the suite of research tools in M8.

3.1.3.2 Project contests

Participants' intrinsic motivation for active engagement in the research processes is also achieved through the organization of three major project contests. In those, participants are incentivized through the opportunity for publicity and prizes that will be awarded for active participation in activities that will provide the research with rich input.

The First Contest will be launched in the Community Workshop and Contest Launch (M13). Its finals and conclusion will be part of the subsequent First Research and Innovation Workshop and Autumn School (M17).

The Second Contest will be launched in the context of the Community Workshop and Contest Launch event in M22. The finals and conclusion of the Second Contest will be during the Second Research and Innovation Workshop and Summer School (M27).

In the framework of the same event, the Third Contest will also be launched, to be concluded with its finals in the Final Conference and Fair (M36).

Overall at least 150 individuals will be engaged with the three contests, and there will be 5 winners per contest (15 winners overall).

3.1.4 Time-appropriate, generic, and context-specific research instruments

For the realisation of the above defined quantitative and qualitative research, the project is currently considering available options for the selection, adoption, adaptation, and, in cases also, new development of appropriate research instruments and tools. Those may include various questionnaires, which will be administered mainly through online surveys, as well as an array of protocols, schedules and guidelines for the realisation of qualitative research through semi-structured personal interviews or focus groups discussions, observations of practices, consultations with participants, and/or other forms of self-reflection and participatory research. A selection of the above may constitute part of the research participants' gameful experience (cf. the Surveys element of the COMnPLAYer App, presented in section 3.1.3 above).

In defining the various research instruments and tools, the consortium aims at ensuring the input required for the next steps in the project as well as valuable scientific contributions beyond the immediate context of the project. Decisions on the approach to follow and the instruments to use are made on the basis of the research questions seeking answers at each stage. Options considered include, for example, both conducting open semi-structured interviews to develop a model (e.g. by applying grounded theory), as well as selecting applicable theories and constructs (e.g. science capital) and adopting validated questionnaires from those.

The eventual suite of research instruments and tools as a whole will comprehensively cover all aspects of the research, allowing the collection of data from the field to provide insights in response to all research questions.

Particular attention will be paid to the appropriate selection of items for the different instruments, so that there is the appropriate tool for the different timeframes of field activity, from short one-off instances of interaction with stakeholders to longer series of repeated instances of interaction.

Overall, at a first level the research tools will be developed in a generic form to allow for some project-level comparisons across language and cultural borders.

At the level of each of the 10 case studies (cf. section 3.1.5 below), the generic research tools may be flexibly localized and applied to the particular local circumstances, so as to realise reliable and credible in-depth research within each case study and within the given time and resource framework of the project. Thus, for each case study generic project-level instruments may be selected, adopted and/or adapted, albeit within specified limitations that will ensure a minimum common core across the project.

Deliverable D1.2 'Research Instruments and Tools' (M8) will include concrete plans for the 10 case studies, and link those to the adoption or adaptation of corresponding generic, project-level research instruments and tools.

3.1.4.1 Current notes on questionnaire surveys

Questionnaire surveys will be used as starting points, focused on investigating larger numbers participants, attempting to ensure coverage of a diversity of individuals, activities and practices.

The content of each questionnaire will be devised on the basis of the research questions seeking answer through a particular survey, and through intensive collaboration in the consortium. List of topics to be covered and corresponding example questions will be discussed and agreed among partners. Items and scales will be designed, including only limited numbers of open-ended questions, and, where possible, piloted to be fine-tuned and validated before the actual survey is launched.

Questionnaires will be mainly offered for completion online. Questionnaire respondents will always be informed about the relevant data policies of the project, and that responses will be subject to the GDPR regulations.

Convenience samples will be used in the surveys, with all consortium partners contributing to the effort of reaching as many practitioners as possible. Questionnaires will be promoted through consortium partners' various channels (e.g. including, but not limiting to, websites, mailing lists, social networks, etc.) and the central communication and dissemination mechanisms of the project (WP4), aiming to maximise participation. Project partners may accompany the general project messages introducing the surveys to the public, with more personal messages encouraging their contacts to participate by highlighting the benefits this can bring to common knowledge as well as any practical gains for the participants.

While flexibility to adjust to the circumstances is allowed, as a general rule each consortium partner should aim to contribute to the overall response to an online questionnaire of the project by attracting at least 50 respondents. In this way, more than 500 responses per survey from a wide variety of European contexts can be achieved.

A specific deadline will be set for each online survey, indicatively 2-3 weeks from the first public circulation of the questionnaire. If required, extensions to the deadline can be agreed.

The consortium will monitor and document the numbers of those invited to respond and compare them with the responses received. This response rate will be of use in the analysis of the gathered data and the reporting of the results, as well as in efforts to improve the reach and success of future surveys in the project.

As an example from the context of WP2, practitioners beyond the consortium are currently being invited to contribute to the pool of practices of the project by completing an online questionnaire of the informal science learning practices survey[8]. This quantitative survey will serve as a starting point in the effort to map the informal science learning community, providing valuable background and guidance to the interviews of a refined qualitative study that will follow.

3.1.4.2 Current notes on interviews

Interviews with selected respondents will generally follow after questionnaire surveys, aiming to look deeper into the nature and impact of informal science learning and those aspects investigated at each point.

The content of each interview protocol will be devised on the basis of the research questions seeking answer at each stage, and through intensive collaboration in the consortium. List of topics to be covered and corresponding example questions will be discussed and agreed among partners. A list of open-ended questions and sub-questions will be devised, serving as guidance regarding the key aspects to be covered during the interview. Where possible, this will be piloted to be fine-tuned and validated before the actual interviews take place.

Interviews will be conducted face-to-face or at a distance, e.g. over the phone or via Skype and similar videoconferencing tools. In case audio conversation is not possible, even online text-based chat might be an option.

Interviewees will always be informed about the relevant data policies of the project, and that responses will be subject to the GDPR regulations. A relevant consent form will be sent to the respondent in advance, who will return it signed before the interview. The consent form will state that the data will be anonymised, that it will be used for research purposes only, that it will not be given to any third party, and that voice records will be played back in the presence of the researchers only.

Interview questions will not be sent to the participant in advance. However, a short description may be provided as an introduction.

At the end of the interview, the person/organisation may be asked whether they would like to be credited on the project web site as a part of the project community, in which case an additional appropriate consent form will be sent.

The analysis of responses to preceding surveys as well as convenience sampling will define who the interviewees will be at each time. All consortium partners will contribute to the efforts of interviewing as many informants from as many diverse contexts as possible, and as

[8] Survey of ISL practitioners: https://forms.office.com/Pages/ResponsePage.aspx?id=cgahCS-CZ0SluluzdZZ8BcqJTJWZcRZOt_S9qp9NsGJUODdGQUQ3U1U3Q0xEME1ITjFWR1JINjFJWi4u

required by the research design. Project partners may accompany the general project messages introducing the interview to the interviewee with a more personal message encouraging their contacts to participate by highlighting the benefits this can bring to common knowledge as well as any practical gains for the practitioners and their practices.

While flexibility to adjust to the circumstances is allowed, as a general rule each consortium partner should aim to contribute at least 5 interviews. In this way, more than 50 interviews at each time from a wide variety of European contexts can be carried out.

A specific deadline will be set for the partners to conduct the interviews, indicatively 2-3 weeks from the launch of the relevant interview cycle. If required, extensions to the deadline can be agreed.

The consortium will monitor and document the numbers of those invited to be interviewed and compare them with the numbers of those actually interviewed. This response rate will be of use in the analysis of the gathered data and the reporting of the results, as well as in efforts to improve future interviews in the project.

As a current example from the context of WP2, selected practitioners beyond the consortium who have been invited to complete the online questionnaire of the informal science learning practices survey will subsequently be invited to interviews. The follow-up interviews will focus mainly on the practitioners, while the preceding online questionnaire survey will have focused mainly on the practices.

The data and information collected through the interviews will be analysed with the use of qualitative methods. There is currently an ongoing discussion in the consortium on this, which has so far yielded the following suggestions regarding the coding and analysis process.

It will be pertinent to apply the Mayring methodology[9], an approach of systematic, rule guided qualitative text analysis which tries to preserve some methodological strengths of quantitative content analysis and widen them to a concept of qualitative procedure.

There is a choice between an inductive (cf. constructing a category system) and deductive (applying a theory-based category system) approach. In practice, the project may adopt a combination of the two, starting with a given category system and expanding and adopting it step by step. It is noted that if the category system is changed during the coding process, all prior codes will have to be re-checked.

It is advisable not to perform inductive coding in parallel, producing different category systems from scratch, as the combination of those in the next steps may be very demanding. It is considered appropriate that two researchers start the coding process on a sample of interviews in the English language, in close collaboration with each other (optimally, sitting side by side), so as to produce a first version of the category system and write a detailed

[9] Mayring, Philipp (2000). Qualitative Content Analysis. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 1(2) 20. Available at: http://www.qualitative-research.net/index.php/fqs/article/view/1089/2385

coding guideline. Based on this, other coders can continue with the coding of the rest of the interviews.

It is noted that quite probably many interviews will be conducted in the local language rather than in English. In many cases it may not be appropriate to translate those non-English interviews fully into English, as this may well lead to substantial loss of meaning. Therefore, it is advisable to provide each local partner with the final category system in the English language, accompanied by coding guidelines and sufficiently detailed anchor examples. This material will then be translated into the local language and applied for the coding of the respective interviews. At the end, specific anchor examples or other important text passages will be translated from the local language interviews into English, to contribute to the general analysis and the reporting of the results to the community.

3.1.5 Towards defining the case studies

The conceptual and methodological framework presented in this report represents the wider context, assumptions and intentions of the project at a general level. These need subsequently to become specific, linked to, and appropriate for, the very diverse realities of the informal science learning practices that the project intends to investigate on the field.

For this purpose, research is already being conducted (WP2) for the identification of several and diverse existing coding, making and play-based practices taking place outside formal science classrooms which, in the light of the conceptual framework developed, appear to bear some promise for informal science learning. To this end, the consortium both draws on its own activities and background, and identifies, invites and motivates other practitioners to contribute their practices to the project.

Using the Template for the Identification of the Consortium's Own Practices included in Annex A of this report, the consortium has identified and gathered the first descriptions of practices that are considered as very relevant to the research and to which project partners may have immediate or relatively easy access for the purposes of the empirical research. Information on these first identified practices, referred to as "the consortium's own practices", has thus far helped refine the focus of the conceptual framework, and, in particular, define a realistic methodological framework by taking into account practicalities of the field, such as practice availability, access to participants, etc.

In the context of ongoing work in WP2, the research is now going deeper into the consortium's own practices, defining them in more detail, as well as identifying, inviting and motivating others beyond the consortium to contribute their practices to the project.

Towards the end of the Preparation phase (M7-M8), drawing from the major practices identified the consortium will carefully select coding, making and play practices that will be the components of the case studies constituting the empirical research in the following project phase.

At least one longitudinal case study will be defined for each of the participating countries, i.e. overall at least 10 case studies.

Each case study will include an orchestration of selected and matched major practices, and the design, organization and preparation of the relevant field research.

Criteria for the selection of practices and the definition of the case studies include comprehensive conceptual, methodological, sociocultural, geographical and disadvantage-related coverage, as well as practicable and realistic planning of the subsequent empirical research within the timeframe and available resources.

For the definition and preparation of each case study, the consortium will analyse and match the characteristics of the practices and the local circumstances, and organize all practicalities before the start of the empirical research in consultation with the practitioners involved. Relevant materials will be prepared where necessary, and a detailed research plan for each case study will be devised for the whole duration of the empirical research. Finally, each case study will be assigned to a project partner (ideally, the local project partner) who will act as the local coordinator and facilitator, being the interface between the communities participating in the field activities and the rest of the project.

Through the use of the above-mentioned Template for the identification of the consortium's own practices (Annex A), 23 practices have been identified and are being considered as strong candidates for the case studies. Those are presented in the table on the following pages, including summary information for each of the practices on the county context, the project partner providing (or seeking) access to the practice, participant age range, the COMnPLAY SCIENCE wide areas covered (coding, making, play), formality and type of the learning space(s), as well as the links to science education. In addition, some further details of the listed practices are provided after the table, including information on the relation of each practice to formal, non-formal and/or informal learning, and its link to science education. It is noted that additional information on field practicalities for each of these listed practices in provided in section 3.1.6.

Deliverable D1.2 'Research Instruments and Tools' (M8) will include concrete plans for the 10 case studies, linking those to the selection, adoption and/or adaptation of corresponding generic project-level research instruments and tools.

Partner	Country	Practices considered for the case studies	Participant age range	COMnPLAY SCIENCE wide areas covered	Formality of the learning space(s)	Types of learning space(s)	Link to science education
NTNU	NO	Kodeløypa workshops	8-17	Coding Making Playful activity	Non-formal Informal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos Community labs, FabLabs	Explicitly linked to STEM education: Science, Technology Not intentionally meant for science learning, science learning a by-product
UOULU	FI	Empowering children with design and making	7-16 (the activities need to be modified depending on the age)	Coding Making Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos Community labs, FabLabs	Explicitly linked to STEM education: Technology
FORTH	GR	Future Designers	7-	Making (using simple materials – not digital tools) Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos	Explicitly linked to STEM education: Technology
FORTH	GR	How to become an inventor… in 10 simple steps (or, How to solve any problem… in 10 simple steps)	5-	Making (using simple materials – not digital tools) Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres,	Explicitly linked to STEM education: Technology

Partner	Country	Practices considered for the case studies	Participant age range	COMnPLAY SCIENCE wide areas covered	Formality of the learning space(s)	Types of learning space(s)	Link to science education
						outreach centres, libraries, zoos	
FORTH	GR	Little Red-Smart-Hood	7-15	Making (using simple materials – not digital tools) Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos	Explicitly linked to STEM education: Technology
TUE	NL	[To be defined in deliverable D1.2]					
UU	SE	SciFest	10-18	Making Playful activity	Non-formal	Fairs, contests, challenges	Explicitly linked to STEM education: Science, Technology, Engineering
TUM	DE	Coding Contest	10-15	Coding Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Technology, Engineering Not intentionally meant for science learning, science learning a by-product
TUM	DE	LOOP: Learning object-oriented programming	13-18	Coding Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Technology, Engineering
TUM	DE	Welcome to the Programming Circus	8-10	Coding Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Technology, Engineering

Partner	Country	Practices considered for the case studies	Participant age range	COMnPLAY SCIENCE wide areas covered	Formality of the learning space(s)	Types of learning space(s)	Link to science education
TUM	DE	Lego Robotics	8-14	Coding Making Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Technology, Engineering
TUM	DE	Lego WeDo: The adventures of Mia and Max	6-10	Coding Making Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Technology, Engineering
UOM	MT	GameJams: designing and developing digital games (or Game Design and Development Workshops)	18-	Coding Making	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Community labs, FabLabs Fairs, contests, challenges	Not intentionally meant for science learning, science learning a by-product
UOM	MT	Playing & Testing Digital Games	8- (primary and high school students, university students, educators, practitioners, stakeholders)	Playful activity	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Community labs, FabLabs Fairs, contests, challenges	Explicitly linked to STEM education Not intentionally meant for science learning, science learning a by-product
DFC	ES	Lab I CAN	any	Making Playful activity	Formal Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Not intentionally meant for science learning, science learning a by-product
DFC	ES	Lab WE CAN	any	Making	Formal	Classrooms, labs, out-of-	Not intentionally meant for

Partner	Country	Practices considered for the case studies	Participant age range	COMnPLAY SCIENCE wide areas covered	Formality of the learning space(s)	Types of learning space(s)	Link to science education
				Playful activity	Non-formal	school/university formal learning spaces	science learning, science learning a by-product
DFC	ES	Workshop I CAN	any	Making Playful activity	Formal Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Not intentionally meant for science learning, science learning a by-product
OVOS	AT	[To be defined in deliverable D1.2]					
KCL	UK	The Invention Rooms, Imperial College London	any (including student population and the local community)	Coding Making Playful activity	Formal Non-formal Informal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos Community labs, FabLabs Everyday life (e.g. personal hobbies, gaming)	Explicitly linked to STEM education: Science, Technology, Engineering, Maths
KCL	UK	Maker space within Science Gallery London	16 – 25	Making	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos	Explicitly linked to STEM education: Science, Technology, Engineering; also Medicine
SMG	UK	NUSTEM	Initiatives ranging from preschool age	Coding Making	Non-formal	Classrooms, labs, out-of-school/university formal learning spaces	Explicitly linked to STEM education: Science, Technology, Engineering,

Partner	Country	Practices considered for the case studies	Participant age range	COMnPLAY SCIENCE wide areas covered	Formality of the learning space(s)	Types of learning space(s)	Link to science education
			to 18			Museums, science centres, outreach centres, libraries, zoos	Maths
SMG	UK	CoderDojo	7-17	Coding	Non-formal	Museums, science centres, outreach centres, libraries, zoos Community labs, FabLabs	Not intentionally meant for science learning, science learning a by-product
SMG	UK	LEGOTinkering	7-11 (primarily)	Making	Formal	Classrooms, labs, out-of-school/university formal learning spaces Museums, science centres, outreach centres, libraries, zoos	Not intentionally meant for science learning, science learning a by-product
SMG	UK	MakerClub (Brighton)	8-13	Coding Making	Non-formal	Community labs, FabLabs	Not intentionally meant for science learning, science learning a by-product
SMG	UK	Wonderlab	Any age can attend, however aimed at age 7+	Playful activity	Informal learning	Museums, science centres, outreach centres, libraries, zoos	Explicitly linked to STEM education: Science, Engineering, Maths

Further descriptions of the above practices are provided below, including some additional information on the relation of each practice to formal, non-formal and/or informal learning, and its link to science education.

3.1.5.1 NTNU, Norway: Kodeløypa workshops

Norwegian University of Science and Technology (NTNU), in Trondheim, Norway, designs and implements a coding activity named "Kodeløypa" (the path towards coding). The workshop's activities are based on the constructionist approach, as one of the main principles of this is learning by making. The workshop is conducted in a largely informal setting, as an out-of-school activity, and lasts for four hours in total. Various student groups, ranging from 8–17 years old, are invited in NTNU's specially designed rooms for creative purposes to interact with digital robots and create games using Scratch and the Arduino hardware platform. Specifically, Arduino is attached to the digital robots to connect them with the computer. At that point, an extension of Scratch called Scratch for Arduino (S4A) provides the extra blocks needed to control the robots. Scratch programming language uses colourful blocks grouped into categories (motion, looks, sound, pen, control, sensing, operators, and variables), with which children can develop stories, games, and any type of animation they imagine. In general, children who attended the workshop work collaboratively in triads or dyads (depending on the number of children). The workshop is designed for children without (or with minimum) previous experience in coding and aims to enhance students' computational thinking, problem-solving, critical thinking and collaborative skills. Combining physical fabrication and coding results in engagement in programming concepts and practices (e.g., testing and debugging).

During the workshop, student assistants were the responsible supporting each team as needed. Approximately one assistant observed and helped one or two teams.

The participants of the workshops are students from schools in Trondheim, Norway, whose teachers/school apply to attend the "Kodeløypa" workshops, (Provided by the Department of Computer Science at NTNU). Responsible for sending an open call invitation to the schools at Trondheim, is "Skolelaboratoriet" at NTNU which is a resource center for teaching science. When the schools are selected, the researchers contact the schools to get the consent from both the child and the legal guardian. Younger participants are students who participate at Kodeklubben (local coding clubs) and want voluntarily to take part in the workshops.

Relation to formal, non-formal, informal learning: The workshop activities are based on the constructionist approach, as one of the main principles of this is learning by making. The workshop is conducted in a largely informal setting, as an out-of-school activity, and lasts for four hours in total. Various student groups, ranging from 8–17 years old, are invited in NTNU's specially designed rooms for creative purposes to interact with digital robots and create games using Scratch and the Arduino hardware platform. Students work collaboratively in teams of two or three. During the workshop, student assistants are the responsible supporting each team as needed. Students get tutorials with instructions with examples and pictures specially designed for the activities.

Link to science education: Developing age appropriate learning materials and instructions. For example, the kids focus more on aesthetics and have lower gaze similarity and learning gain, so instructors should ensure that children in the young age bracket of 8–12 receive guidelines on where to pay attention when they code (such as commands and output).

The learning environment should support collaboration within teams and good communication, so that all members get the advantage of each other's help.

Keep student's motivation high, motivated children with positive attitudes have better management of cognitive load, as was represented by their eye movements. Our findings demonstrate that the way children perceive the cognitive load from the learning process is related to their attitudes.

The design of the aesthetics of the visual coding tool is important to give a pleasant sense for children's use, but it should also help them indicate in a clear way the input and output values while coding. One example could be the clear representation of code segments and less complexity in scripting (e.g. fewer sprites and stacks of code). Another thought might be the design of dynamic coding tools that could be further developed according to children's progress in the coding task, such as starting with fewer code segments and gradually providing more advanced coding possibilities in relation to progress.

3.1.5.2 UOULU, Finland: Empowering children with design and making

We (senior researchers with a team of junior researchers) have worked with local schools (volunteering teachers and their classes) so far, but the projects can be carried out in informal learning settings as well, e.g. in different kinds of hobby related clubs. Teachers have set certain learning goals for the projects, but they have been quite informal and no assessment has been conducted. Children have been invited to reflect on their experiences and learning in different kinds of situations: interviews, essay writing. The projects have lasted for several months, including child led ideation, design, making, programming, evaluation, and reflection. Children have been given freedom to decide on the project topic and they have worked on the topic is small groups (. The premises of the schools have been utilized as well as the Fab Lab of the University of Oulu. Different kinds of playful tools (e.g. Robots, LEGOs) as well as digital fabrication equipment has been in use. The goal has been children's technology education (e.g. design, making, programming, computer education, familiarizing with design thinking, maker movement). The projects have developed different kinds of games and they have included game playing by children.

Relation to formal, non-formal, informal learning: The practice has certain aims and goals around which the participants are invited to reflect on their experiences. Teachers have been important participants, too. However, the projects have included a lot of flexibility and freedom: teachers and researchers both have been interested in engaging on this type of creative and open-ended exploration with children.

Link to science education: This practice is linked to technology education in particular.

3.1.5.3 FORTH, Greece: Future Designers

'Future Designers' is an interactive and participative crash course that aims to introduce to children the concepts and practice of creativity, design, and design thinking. The course combines various learning approaches and tools, including lecturing (using a variety of media such as images, videos and music), creative question & answer, constructive – personal and collaborative – hands-on activities, play, humor and fun.

The full course can last 2-5 hours and can be delivered in a single or two sessions.

The course has been implemented in several pilot studies with primary, middle and high school students, as well as with primary school children with their parents, and teachers.

Relation to formal, non-formal, informal learning: It is a planned, organised and structured activity, but with on validation of certification. The children's outcomes are not judged or predetermined. It can take place in any location, as long as participants have a surface to write, draw, create and cooperate.

Link to science education: The practice introduces and explains design and creative / design thinking, triggers critical thinking and includes creative / design activities.

3.1.5.4 FORTH, Greece: How to become an inventor... in 10 simple steps (or, How to solve any problem… in 10 simple steps)

A 2.5 hours course introducing inventors, inventions, patents, creative ideas and how to produce them, as well as a 10-step iterative process for creating your own inventions. The course comprises 6 constructive activities and is targeted to groups of 8 – 16 participants. Up to now, it has been applied with children 10-12 years old, and 6-years old children collaborating with one of their parents.

Relation to formal, non-formal, informal learning: It is a planned, organised and structured activity, but with on validation of certification. The children's outcomes are not judged or predetermined. It can take place in any location, as long as participants have a surface to write, draw, create and cooperate.

Link to science education: The practice introduces and explains creativity and creative thinking, design processes and critical thinking and includes creative / design activities.

3.1.5.5 FORTH, Greece: Little Red-Smart-Hood

Up to now the practice has been used twice a 60' workshop, at an Educational Festival in Greece. The goal of the workshop was to introduce children (as well as their parents and teachers who were allowed to watch the workshop) to some emerging technologies, as well as to the "Little Red-Smart-Hood" online book, the resources it offers and how they can take advantage of them.

Who: 30-40 Primary and Middle School Children (7-15 years old); Duration: 60'

How: A small selected subset of the text and corresponding technologies included in the "Little Red-Smart-Hood" online book (see below) were presented using PowerPoint, accompanied by interactive discussion and critical thinking questions, and design and making activities were performed using non-technological materials. More specifically:

Technology	Approach
Smart Fabric Sensors Smart clothes	Presentation of related images & videos Critical thinking questions (open discussion) Design activities (pen & paper) Imagine and write/draw a new type of sensor that you would like to exist Draw on a post-it note a technology and stick it on one of your clothes to make it "smart" (Children were given a picture from an old schoolbook depicting a classroom) If this was a picture form a future classroom, and the teacher and children were wearing smart school clothing what they would be able to do? You can also sketch over the image to change their clothes.
Smart pillow	Design activity (Children were given a picture of "blank" pillow) What do you think that a smart pillow would be able to do? You can also sketch over the image. Presentation of related images & videos Critical thinking questions (open discussion)
Smart refrigerator	Presentation of related images & videos Critical thinking questions (open discussion) Design activity If you had a smart fridge how would you name it
*** COMBINATORIAL DESIGN ACTIVITY ***	Design activity (pen & paper) If you had a personal smart piece of clothing, a smart pillow and a smart fridge, how could they cooperate to offer you additional services?
Mixed reality glasses	Presentation of related images & videos Design activity Create your own pair of mixed reality glasses using a sheet of aluminum foil. Presentation of the glasses mentioned in Frank Baum's Master Key novel Design activity Wear your smart glasses and draw how you see the world through them. How do they enhance reality?
Drone	Presentation of related images & videos Critical thinking questions (open discussion) Design activity Create a "drone" using paper & a paperclip.

The practice is based on an online book and related resources (available in Greek), entitled "Little Red-Smart-Hood". The text is an adaptation of the original Grimm Brothers' version of the "Little red cap" (or, riding hood) fairytale, "updated" with, state-of-the-art and emerging technologies.

The goal of this digital publication is to aid children (of all ages) to learn more about technologies that already affect their everyday lives or, are expected to shape their futures, and critically think (but also using humour) about them, overcoming the initial wow factor that these technologies create. Each technology mentioned in the text constitutes a link to a page of a separate part of the book entitled "Smartopedia". Each Smartopedia page includes a brief, easy to understand, description of the technology, its goals and uses, followed by critical (often humorous) questions, suggestions for further Web searching, creative / design activities and constructive fun games.

Note: The online text has also been used in a school setting with 11-12 year-old-children. They read aloud the whole text and then discussed about its contents.

Relation to formal, non-formal, informal learning: It is a planned, organised and structured activity, but with on validation of certification. The children's outcomes are not judged or predetermined. It can take place in any location, as long as participants have a surface to write, draw, create and cooperate.

Link to science education: The practice introduces and explains (new) technologies, triggers critical thinking regarding their potential positive and negative impact, potential benefits and problems, and also includes creative / design activities allowing children to imagine their own adaptations, based on their ideas, needs and preferences.

3.1.5.6 UU, Sweden: SciFest

SciFest's core idea is to offer a wide variety of trial-on activities in the form of workshops and drop-in activities. While being informed about the activities of universities, schools and companies, the intention is that visitors will be curious about science and want to learn more.

Relation to formal, non-formal, informal learning: Exhibitors and participants at SciFest come from schools and universities as well as companies, authorities, museums and organizations. Many are young students, researchers and innovators who help inspire other young people.

Link to science education: The activities aim to expose students to aspects of research and development with applications for society and technical development. Through the fair we hope to enhance the enthusiasm of young people for science and help them to better appreciate the contributions of science and engineering to their everyday lives.

3.1.5.7 TUM, Germany: Coding Contest

The Technical University of Munich (TUM) plans to measure the computer science competencies of Bavarian students in the sense of PISA in a Bavarian-wide coding contest.

The contest is intended to interest and motivate students in coding and computer science in general.

The students will be given interesting tasks related to their everyday lives in a playful way.

All items are IRT-based and piloted in advance.

Link to science education: This contest shall measure the computer science competencies of Bavarian students.

3.1.5.8 TUM, Germany: LOOP: Learning object-oriented programming

The Technical University of Munich (TUM) regularly offers LOOP, an introductory MOOC course to learn the basics of object-oriented programming (currently in the German language) for students and prospective students of the TUM.

TUM plans to redesign this course and offer LOOP to interested young people aged 13-18.

The aim is to teach young people how to program in a playful way. Using various examples, the students learn to write their own programs and solve programming problems. They can form groups online to exchange information and solve problems collaboratively.

Local face-to-face events can be organized to support the community.

Relation to formal, non-formal, informal learning: Structured online course to get students enthusiastic about programming. The focus is on learning of object-oriented programming in a playful way.

3.1.5.9 TUM, Germany: Welcome to the Programming Circus

The Technical University of Munich (TUM) designed a three-day course for younger children (aged 6-9) to learn the basic principles of programming.

To attract both girls and boys, the course is designed under the motto ”programming circus”, which should be appealing to both genders.

The children attend the workshop for 4 hours a day:

Day 1. The aim of the first day is to give the students a basic idea of how computer programs work. To achieve this objective without the distraction of learning a programming environment at first, an unplugged approach is chosen. The students program each other to find missing items and animals in a symbolic circus tent.

Day 2. On the second day, students create simple multimedia products using the block based language Scratch. For example, the children program the welcome greeting from the circus director, a joke telling clown and a dancing bear. The students first follow handed-out instructions and solve more open tasks afterwards.

Day 3. On the last day the students work on open tasks. They create their own circus story following several specifications like using a variety of characters or a repetition. At the end of the course, the projects are presented to the class and experiences are discussed with the students.

The course was held several times in 2016. To analyse the interactions of the kids with each other and with the teacher, the entire workshops where recorded on video.

Relation to formal, non-formal, informal learning: Structured course that takes place outside of the classroom to get younger children excited about programming.

3.1.5.10 TUM, Germany: Lego Robotics

The Student and Research Centre of the Technical University of Munich, situated in Berchtesgaden, Germany designed and established a robotics workshop for beginners.

The primary concern of the centre is to inspire young people to become interested in STEM subjects and to introduce them to and support them in research work. Individual students are offered STEM-workshops throughout the whole year, as are entire school classes. The courses last from a few hours up to several days.

The Lego EV3 Starter Workshop is aimed at children aged 8-11 and is an introductory course in robotics and programming. Students explore the basics of what it takes for their robot to interact independently with its environment. Using different sensors, they solve various problems by programming their robot through visual coding.

The children work collaboratively in groups of 2-3 participants using a problem-based approach.

During the workshop the students are supported and encouraged by an educator where necessary.

At the end all results are presented by the individual groups. Family members are then invited to join the course and to get an introduction by their children.

Relation to formal, non-formal, informal learning: Although a lot of school classes attend the course, it is non-curricular based.

The workshop is well structured, the activities are planned. The main intention is to get the students involved in their own projects and to raise interest in STEM subjects. Learning objectives are secondary.

3.1.5.11 TUM, Germany: Lego WeDo: The adventures of Mia and Max

The Student and Research Centre of the Technical University of Munich, situated in Berchtesgaden, Germany designed and established a robotics workshop for beginners.

The primary concern of the centre is to inspire young people to become interested in STEM subjects and to introduce them to and support them in research work. Individual students are offered STEM-workshops throughout the whole year, as are entire school classes. The courses last from a few hours up to several days.

The Lego WeDo workshop is aimed at younger children (6-10 years) and encourages the students to build various figures using Lego WeDo by a hands-on approach. After building and learning more about mechanics they bring the figures to life through visual programming. For the first time sensors are used so that the figures react to external influences.

The children work collaboratively in groups of 2-3 participants using a problem-based approach.

During the workshop the students are supported and encouraged by an educator where necessary.

At the end all results are presented by each individual group. Family members are also invited to attend the course to receive an introduction from their children.

Relation to formal, non-formal, informal learning: Although a lot of school classes attend the course, it is non-curricular based. The workshop is well structured, the activities are planned. The main intention is to get the students involved in their own projects and to raise interest in STEM subjects. Learning objectives are secondary.

3.1.5.12 UOM, Malta: GameJams: designing and developing digital games (or Game Design and Development Workshops)

The Institute of Digital Games (IDG) of the University of Malta has been organising gamejams where participants are invited to design and develop a playable game, on a set theme, in a limited time-frame. The most recent event was the organisation of the Malta chapter of the Global Game Jam event, on the 26th to 28th of January 2018 (http://www.game.edu.mt/blog/idg-hosts-the-malta-global-game-jam-for-the-6th-time/).

In the framework of the gamejams, the participants are given a specific theme (e.g. "Waves") and are asked to design and develop in groups a relevant digital game.

Such gamejams can be viewed as creative informal computer science learning activities linked to the design and coding, and familiarizing young people with the world of game design and development. Participants are aiming to design engaging games, to express their creativity, formulate strategies for approaching the task, solve problems, collaborate, and develop a digital artifact (game) through coding or other relevant tools and applications.

Such events can be therefore linked to: computer education, computational thinking, problem-based learning, problem-setting and solving, collaborative learning, and design thinking.

Gamejams are also key-events for the establishment of a vibrant local and international community of people interested in expressing their creativity, and also interested in digital games.

Game design and development workshops could potentially be organised with a similar format but adjusted to the project's goals, requirements, and target group.

Participation in gamesjams is typically open and voluntary, but could probably be adjusted: schools or students and educators could be invited to participate in a gamejam with a potentially learning or educational framework.

Relation to formal, non-formal, informal learning: The gamejams typical take place at the University of Malta campus. They could, nevertheless, take place in venues that fulfil certain conditions (e.g. space for the participants to design the games, use their computers, collaborate in groups, present their games, attend lectures and presentations, rest).

The events are planned, organised and structured, with set goals (i.e. the theme of the game, a specific time-frame) allowing, though, the participants the time and space to engage their creativity through the design and development of a digital game.

They are not explicitly designed for learning but throughout the activity participants are required to exhibit relevant skills and knowledge (e.g. coding skills, collaboration skills, subject related knowledge).

Link to science education: The main objective of the gamejams is for the participants to design and develop their game. Participants, though, will have to formulate hypotheses and make predictions, plan methodology and approach, solve problems, experiment, understand the interdependence of factors, analyse data, answer questions, make conclusions, understand processes, make decisions, possibly research concepts relevant to Science subject matters depending on the theme of the gamejam.

The game design and development workshops would also be adjusted (e.g. the theme of the games, the requirement of a playable game) to address specific learning objectives of STEM or other Sciences (Natural, Social) in the framework of the project.

3.1.5.13 UoM, Malta: Playing & Testing Digital Games

At the Institute of Digital Games (IDG) of the University of Malta, we have locally been in visiting venues and having kids/educators testing our games. We have also organised relevant training events (e.g. training events, workshops) for educators, practitioners, and stakeholders, during, for instance, the yearly “Researchers’ Night”.

One example of such an event will be held on 28th September 2018, during the “Science and the City” exhibition. The IDG will be showcasing showcasing game design and research at their stand, and also inviting to try out games developed by students of the Institute.

For such events, games produced in UoM’s successful research and innovation projects are deployed. The participants are invited to play with the games. Data regarding their engagement and interaction with the game are collected during the activity, through observation or computational tools integrated in the game, or after through questionnaires and interviews.

Examples of games that have been or could potentially be used are the following:

ENVISAGE: ENhance VIrtual learning Space using Applied Gaming in Education. Game analytics have also been implemented for this game.

C2Learn: Fostering Creativity in Learning through Digital Games

eCrisis: Europe in Crisis. A game on social inclusion.

Village Voices. Developed in the framework of the Siren Project and also implemented in the eCrisis project. A collaborative game for leaning on conflict resolution. Aiming to also support teachers' role to educate young people on how to resolve conflicts.

Playtesting sessions can be linked to areas such as: game-based learning, learning through games, playfulness, and collaborative learning (depending on the digital game used).

The scenarios of such activities can be specifically adjusted to themes and concepts of the project (i.e. science learning).

Such activities and events, combined with frequent game lectures, training sessions, and workshops organised at the IDG, have allowed us to form links, and communication and collaboration channels with the local community, learners, state schools, educators, practitioners, policy-makers and stakeholders.

Relation to formal, non-formal, informal learning: Playtesting events have been taking place at the University of Malta campus, the Institute of Digital Games Computer Lab.

Participants play digital games specifically designed for learning. Although this is a playful, out-of-school activity, the environment of the digital games is highly structured with specific goals and constraints. These digital games are nevertheless games with intrinsic motivation and engagement being a core objective as well as the integrated learning element.

Playing digital games is typically an informal, free-time activity for the majority of the participants. These events, though, for the purposes of studying the impact and effectiveness of the games, are organised and structured: the participants are introduced to the games, they play the games in the lab, and then encouraged to reflect and discuss about their experience.

Link to science education: These events may have an explicit or an indirect STEM related learning goal or impact depending on the content of the digital game. For instance, virtual environments such as the online virtual labs developed for the ENVISAGE project, emulate real laboratories where students can accomplish a number of learning tasks are mainly oriented towards subjects such as physics and chemistry (Science learning goals), while for games such as "Village Voices" science learning can be a by-product as the participants (e.g. students) have to engage in tasks involving understanding of processes and interdependence of factors and variables, solving problems, be critical, make decisions, and creative thinking.

3.1.5.14 DFC, Spain: Lab I CAN

Labs I CAN are directed to anyone of any age who wants to explore and learn the Design for Change (DFC) methodology, which promotes innovation in education, social entrepreneurship and encourages the I CAN Mindset in children and young people, to empower them to change the world starting with their own environment. DFC is based on design thinking, empathy, creativity, shared leadership and collaborative learning.

Laboratories, designed specially for educators, help them innovate by learning the DFC methodology and experimenting the complete 5-phase methodology – Feel, Imagen, Do, Evolute (Evaluate + Evolve), Share. To enrich and facilitate day-to-day life in the classroom, in the school and in the management team. Through play, as well as reflection and the generation of conversations, educational resources are offered that allow participants to change their mindset, help them be empowered and become a facilitator of the DFC process.

Educators can specially learn how to boost their students' motivation by means of the methodology in any subject or field, in formal as well as informal education. A complete experience of how problem solving in any context or related to any community issue or challenge can be addressed with team work, creative thinking, prototyping and curiosity.

These 12-hour trainings, developed by two DFC Spain practitioners, are ideal for groups of 20 to 25 people, and are structured in:

Complete practical development of the phases of the DFC methodology.

Practices as facilitators.

Games and dynamics to connect, balance, develop skills...

Advice and resolution of doubts. Looking to the future, how will they implement it?

Relation to formal, non-formal, informal learning: Labs I CAN can be given in any space and for any organization who is interested in DFC, including formal schools as well as non-formal education organizations.

They are planned activities, organised and structured, and for Labs we do give certification.

Link to science education: Labs I CAN are not directly linked to any subject or field. Educators who experience the lab can later adapt the DFC methodology to their own field. Children who later initiate a DFC project following the 5 step model, are the ones to choose the problem, design the solution, and carry out the project, and in some occasions, the problem and/or the problem-solving process are related to STEAM.

3.1.5.15 DFC, Spain: Lab WE CAN

Labs WE CAN are directed to anyone who has already experienced a Lab I CAN and wants to explore further the Design for Change (DFC) methodology, which promotes innovation in education, social entrepreneurship and encourages the I CAN Mindset in children and young people, to empower them to change the world starting with their own environment. DFC is based on design thinking, empathy, creativity, shared leadership and collaborative learning.

These laboratories are the natural continuation of the Labs I CAN. The content goes a step further in the DFC methodology and goes deeper to places never imagined, to continue providing new tools to those who have already undertaken a DFC project.

Educators can specially learn how to boost their students' motivation by means of the methodology in any subject or field, in formal as well as informal education. A complete experience of how problem solving in any context or related to any community issue or challenge can be addressed with team work, creative thinking, prototyping and curiosity.

Like the Labs I CAN, Labs WE CAN are 12-hour training sessions developed by two practitioners from DFC Spain, ideal for groups of 20 to 25 people.

Relation to formal, non-formal, informal learning: Labs WE CAN can be given in any space and for any organization who is interested in DFC and has already experienced a Lab I CAN, including formal schools as well as non-formal education organizations.

They are planned activities, organised and structured, and for Labs we do give certification.

Link to science education: Labs WE CAN are not directly linked to any subject or field. Educators who experience the lab can later adapt the DFC methodology to their own field. Children who later initiate a DFC project following the 5 step model, are the ones to choose the problem, design the solution, and carry out the project, and in some occasions, the problem and/or the problem-solving process are related to STEAM.

3.1.5.16 DFC, Spain: Workshop I CAN

Training pills for anyone of any age who wants to explore and learn the Design for Change (DFC) methodology, which promotes innovation in education, social entrepreneurship and encourages the I CAN Mindset in children and young people, to empower them to change the world starting with their own environment. DFC is based on design thinking, empathy, creativity, shared leadership and collaborative learning.

An intense educational-inspiring practice full of surprises that invite reflection through listening and conversation generation. Complex capacities are stimulated with simple exercises to let creativity flow and to promote the I CAN Mindset, as well as fundamental life skills in general. Educators can specially learn how to boost their students' motivation by means of the methodology in any subject or field, in formal as well as informal education.

Workshops generally last between 2 and 4 hours and are facilitated by one DFC Spain practitioner. The workshop is a short version of the complete 5-phase methodology – Feel, Imagen, Do, Evolute (Evaluate + Evolve), Share - experienced in the Labs I CAN (12 hour trainings), where the participants experience the complete DFC process. A glimpse of how problem solving in any context or related to any community issue or challenge can be addressed with team work, creative thinking, prototyping and curiosity.

Relation to formal, non-formal, informal learning: Workshops can be given in any space and for any organization who is interested in DFC, including formal schools as well as non-formal education organizations.

They are planned activities, organised and structured, but for workshops we do not give certification.

Link to science education: Workshops are not directly linked to any subject or field. Educators who experience the workshop can later adapt the DFC methodology to their own field. Children who later initiate a DFC project following the 5 step model, are the ones to choose the problem, design the solution, and carry out the project, and in some occasions, the problem and/or the problem-solving process are related to STEAM.

3.1.5.17 KCL, UK: The Invention Rooms, Imperial College London

The Invention Rooms are a mixture of workshops, design studios and interactive spaces that will bring together our neighbours from the local community with Imperial's academics, students, alumni and partners to get creative, build prototypes and share in the fun of making and discovery.

This includes a:

Reach out Makerspace – a workshop and design studio for young people from the local community to gets hands-on experience of making and protoyping.

Advanced Hackspace – a cutting-edge workshop facility to devleop new ideas and prototypes (this will be for university staff and students, but there may be opportunities for others (inluding young people) to get involved)

Interaction Zone – a space for workshops and tech drop-in activities designed as a welcoming space for the local community.

Relation to formal, non-formal, informal learning: The Invention Rooms (non-formal spaces) are part of Imperial College's West London campus (formal education) seek to support local engagement in research and education. They offer a range of programmes (many are informal, some complement formal education).

3.1.5.18 KCL, UK: Maker space within Science Gallery London

The maker space with 3-D printing facilities will focus on solving real-life (serious) problems in innovative/creative ways.

The space will be associated with an exhibition programme addressing current research in anatomical and physiological science and medicine, specifically focussing on practices connected with the use and design of prosthetics.

Relation to formal, non-formal, informal learning: Connected to formal science research, activities will be managed and strucutred to a certain extent, but will allow participants to explore their own ideas.

3.1.5.19 SMG, UK: NUSTEM

NUSTEM aims to support children, young people and their key influences, to help them make informed choices about STEM careers, using learning from Science Capital, the maker movement, and general informal STEM learning. They also work with children's key influences. Teachers, parents, carers and other family members, and friends.

They try to interact with young people repeatedly over a period of years, to provide 'drip-feed' of their ethos and ideas (That physics is about exploring the world, and that these explorations can be delightful, surprising and satisfying). These interactions might be direct – through workshops and events – or indirect, through NUSTEM materials or via teachers. Some of the activities, particularly in secondary school are aimed specifically at girls. Much of the work is delivered through a number of partner schools (currently 15 primary, 15 secondary).

Some example programmes that might be useful to research: The Science for Families initiative is a five-week course delivered to primary school students (age 5-11) and their parents or guardians (https://nustem.uk/science-for-families/science-families-background/). Every experiment or demonstration is repeatable at home. The resources are cheap. Each experiment offers the opportunity for families to work closely together on something that's likely to be new for everyone. It's about breaking down the perceived barriers of STEM amongst family groups with communities who don't typically engage with STEM.

Shortly they will be starting an Engineering for Families and Digital Making for Families programme.

The activities themselves are fun, creative, and emphasise curiosity, taking learning from making and tinkering best practice. Where possible self-led learning is promoted.

Relation to formal, non-formal, informal learning: The practice is part of Northumbria University and works with a number of local schools however the sessions and various activities happen outside of formal learning hours. The vast majority are structured sessions and where possible includes parents and guardians of young people, recognizing the huge influence these people have on young people's perception of STEM.

Link to science education: The purpose of the programme is to help young people make informed decisions about STEM careers and education.

3.1.5.20 SMG, UK: CoderDojo

CoderDojo is a global volunteer-led community of free programming clubs for young people between 7 and 17. The Science Museum holds one or two of these clubs once a month. Each class consists of a one-hour programming session where participants can try coding for the first time, take part in a specially designed coding activity or just work on their own project, followed by a 'show and tell' session where they can share their projects with the rest of the group.

Participants choose what they want to create, whether this is learning coding basics, building a website, creating an app or game or just exploring technology in an informal, creative, and social environment. Participants can go at their own pace and decide how they want to work – on their own or teamed up. From total beginners to programming masters, everybody is welcome and expert Mentors are available to lend a hand if needed.

Within the CoderDojo Movement there is a focus on peer learning, youth mentoring and self-led learning. The aim is to help young people realise that they can build a positive future through coding and community.

An example session – In October the session will include the coding languages HTML, CSS and Scratch, and there will also be some Micro:bits available to play with (which can be programmed in either Scratch or MicroPython)

Relation to formal, non-formal, informal learning: CoderDojo is not curriculum based and every Dojo covers different topics. The focus is on self-led learning and youth mentoring. Ours happen in the Museum itself however others happen all over the world. All tend to be out of formal learning hours (i.e. not during school time)

3.1.5.21 SGM, UK: LEGOTinkering

LEGOTinkering is a hybrid of LEGO and the term “Tinkering” which has been developed by LEGO Foundation partners at the Tinkering Studio at the Exploratorium, MIT Media Lab, and other in the Maker Movement. The Science Museum Group are now helping with pilot activities.

LEGOTinkering is about creating conditions for the child to “build anything they can imagine” (The LEGO Idea). In the LEGO spectrum between ‘Building to Instruction’ and ‘Free building’, LEGOTinkering is closer – but not the same as – free building. The activities should invite the child to develop their initiative and curiosity, leaving room for the child to lead their experience. In doing so they develop their curiosity, ideas, and goals. At the same time, it’s important to make sure they have a clear invitation to create, and an easy way to get started.

The LEGOTinkering Exploration box has two goals. The first is to create a great open-ended play experience for children. These explorations must be both easy to understand and easy to facilitate for educators new to open-ended creativity. Additionally, they must make compelling invitations for children to follow their curiosity and create new and interesting projects.

The second goal is more experimental and has to do with the educators who are using the box. The aim is to invite them to pay close attention to the children and reflect on what is happening as they are learning through play with the activities.

The first LEGOTinkering Exploration box contains elements to build several open-ended activity explorations using a pull string motor. Each exploration comes with a set of instructions to build a “base model” as a starting point. Children are encouraged to continue building beyond the base model and make something new that reflects their own interests and understanding. Educators are encouraged to document and share these moments of creativity, to deepen their understanding of learning through play, and to encounter facilitation approaches that support child-led inquiry.

A prototype activity, Moving Machines, has been created that allows for different building challenges and tinkering opportunities. The activity has several themes that focus on different mechanical aspects. The instruction guide assists in creating a basic module before separating to three different models to build on this. The first one focuses on arm movement, the second on gearing and the third on linkages. Each challenge gets progressively more complex.

Relation to formal, non-formal, informal learning: Currently in its pilot phase, the overall aim is for the kits to be provided to schools worldwide however in the pilot phase the activities will be trialed in a variety of places including the Museum

3.1.5.22 SGM, UK: MakerClub (Brighton)

MakerClub is an invention and design club which allows young people to develop the skills they need to improve the world around them. This may mean fighting global challenges like climate change; developing AI powered cardboard robots, or creating interactive 3D printed art pieces. The key is that they spend time developing life-long learning skills, a team based mentality and a growth mindset.

Inspired by MIT, MakerClub Brighton is a high-tech makerspace custom built for young makers, fully-equipped with 3D printers, laser cutters and bespoke electronics. Expert tutors take members through hands-on projects covering robotics, coding, 3D design and more. Inventions and challenges are constantly being added to and principles of design thinking encouraged, learning how to come up with good ideas, prototype, and making them a reality.

Relation to formal, non-formal, informal learning: Kids can choose a 'curriculum' working through monthly challenges (Maker – learning the basics; Engineer; Inventor; Master Maker) however the projects are self-led

3.1.5.23 SGM, UK: Wonderlab

Both Wonderlab at the Science Museum in London and at the National Science and Media Museum in Bradford invite audiences to explore science and maths through memorable interactive experiences of scientific phenomena and mathematics principles. The galleries are filled with interactive exhibits and immersive experiences aimed to engage children and adults alike. Many of these exhibits are open ended and encourage play and social interaction. Visitors can also engage with the Museum's explainers to further explore content, either at the exhibits themselves or through various science shows and demos.

Science and maths are organic and dynamic. The galleries are as much about engendering scientific habits of mind, or skills, as it is about conveying scientific concepts. We want people to observe phenomena using all their senses, form ideas, and ask questions. Through the accompanying interpretation it makes links to how these phenomena feature in everyday life.

Scientific habits of mind: Inspire curiosity, scrutiny, questioning and creativity

Relation to formal, non-formal, informal learning: Wonderlab is open to the public with no need to prebook (although there is a charge for the London gallery). Interaction with staff and facilitators are optional.

Link to science education: Although Wonderlab in London is split into thematic/subject areas (Sound, Matter, Light, Waves, Space, Forces, Maths, Electricity) the gallery's objective are about promoting curiosity and habits of mind rather than fact delivery.

3.1.6 Adaptation to local realities

For each of the above listed 23 practices that are being considered as candidates for the case studies, additional information has been collected, relating to field realities and practicalities that need to be taken into account for the final definition of the case studies and the corresponding methodological decisions for each one of them. This information is presented in the table on the following pages, including details on:

- the 'ownership' of, and accessibility to, the practice (i.e. whether the practice is performed by the partner, or is in any other way immediately accessible by the partner for research purposes; or whether the practice is considered as particularly interesting for COMnPLAY SCIENCE, but access to it needs to be agreed with its 'owners')
- place of implementation (country, area, institution)
- the typical duration of the activities (e.g. length of a full cycle, etc)
- time of implementation and any relevant restrictions
- possibility for research team's direct interaction with learners and possible forms of research
- probable numbers of participants.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
NTNU	NO	Kodeløypa workshops	Practice performed by the partner / immediately accessible by the partner for research purposes	Norwegian University of Science and Technology (NTNU), Department of Computer Science, Trondheim, Norway	Kodeløypa workshops run during Autumn semester each academic year; approximately ten workshops are conducted. Depending on the need, workshops can also run different time of the year. Each workshop lasts 1 to 2 days (five to ten hours) in total.	September-October-November 2019 September-October 2020 (if possible)	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity Note: NTNU developing age appropriate learning materials and instructions (In Norwegian). Standardized surveys to assess students attitudes during the coding activity (available in English and Norwegian).	During Autumn semester approximately 9 workshops are conducted with 14-20 participants each. The project aims at 140 participants.
UOULU	FI	Empowering children with	Practice performed by	Oulu, Finland	Several months, weekly meeting/classes/workshops		questionnaire surveys	Difficult to know, 10-20 per project

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
		design and making	the partner / immediately accessible by the partner for research purposes INTERACT Research Unit, University of Oulu, has been developing and experimenting with the practice		with children		individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	
FORTH	GR	Future Designers	Practice performed by the partner / immediately accessible by the partner for research purposes The practice was developed and is performed by Dimitris	Heraklion, Greece. It can be implemented at the premises of FORTH, as well as in local schools (e.g. during an afternoon or weekend as an extracurricular activity) or in the context of various education-related	The workshop was can last from 2 to 5 hours.	No restrictions	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity	Any number between 10 and 30

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			Grammenos, FORTH.	annual events organized by various local organisations or authorities. It can potentially also be implemented in other cities, in cooperation with organizations and schools FORTH collaborates.			other forms of intensive self-reflective participatory research	
FORTH	GR	How to become an inventor... in 10 simple steps (or, How to solve any problem... in 10 simple steps)	Practice performed by the partner / immediately accessible by the partner for research purposes The practice was developed and is performed by Dimitris Grammenos, FORTH.	Heraklion, Greece. It can be implemented at the premises of FORTH, as well as in local schools (e.g., during an afternoon or weekend as an extracurricular activity) or in the context of various education-related annual events organized by various local organisations or	The workshop lasts 2 to 3 hours.	No restrictions	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective	Any number between 10 and 20.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
				authorities. It can potentially also be implemented in other cities, in cooperation with organizations and schools FORTH collaborates.			participatory research	
FORTH	GR	Little Red-Smart-Hood	Practice performed by the partner / immediately accessible by the partner for research purposes The practice was developed and is performed by Dimitris Grammenos, FORTH. He holds the copyright for all online material, which can also be translated.	Heraklion, Greece. It can be implemented at the premises of FORTH, as well as in local schools (e.g., during an afternoon or weekend as an extracurricular activity) or in the context of various education-related annual events organized by various local organisations or authorities. It can potentially also be implemented in other cities, in	The workshop was designed to last 60' but can run up to 180'.	No restrictions	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	Any number between 10 and 40. Fewer participants allow for more discussion and interaction. On the other hand, more participants means more variety of backgrounds and interests, and thus more diverse and unexpected ideas and opinions. Probably the best balance

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
				cooperation with organizations and schools FORTH collaborates.				between the two is with 20-25 participants.
TUE	NL	[To be defined in deliverable D1.2]						
UU	SE	SciFest	Practice performed by the partner / immediately accessible by the partner for research purposes The fair is arranged and coordinated by Uppsala University, many of the activities are arranged and carried out by staff of the university and related stakeholders.	Uppsala Sweden, Uppsala University	A three-day event targeting school classes and the general public, school classes who visit the fair may also book a visit. The event is held in March every year, next event March 2019.	Annual event in March.	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity	In 2018 the fair was visited by over 8000 students and members of the general public.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
TUM	DE	Coding Contest	Practice performed by the partner / immediately accessible by the partner for research purposes	The test is available online. However, students will participate in a supervised environment (e.g. classroom).	45 minutes	Fall 2019	questionnaire surveys individual interviews observations of activity	>100
TUM	DE	LOOP: Learning object-oriented programming	Practice performed by the partner / immediately accessible by the partner for research purposes	Online course of the Technical University of Munich	6 weeks with a weekly workload of approx. 2-3 hrs.	Not before the second half of 2019.	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	>50
TUM	DE	Welcome to the Programming	Practice performed by	Technical University of	3 days / 4 hours	No future dates are planned yet	questionnaire surveys	10-15

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
		Circus	the partner / immediately accessible by the partner for research purposes	Munich			individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	
TUM	DE	Lego Robotics	Practice performed by the partner / immediately accessible by the partner for research purposes	The Student and Research Centre of the Technical University of Munich, situated in Berchtesgaden, Germany	Two workshops: Introductory workshop: 3 hours Extended workshop: 3 days / 3 hours	Recurring regularly / 30 workshops a year	questionnaire surveys individual interviews group interviews/focus groups discussions observations of	Introductory workshop: 15 participants Extended workshop: 10 participants

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
							activity other forms of intensive self-reflective participatory research	
TUM	DE	Lego WeDo: The adventures of Mia and Max	Practice performed by the partner / immediately accessible by the partner for research purposes	The Student and Research Centre of the Technical University of Munich, situated in Berchtesgaden, Germany	3 hours	Recurring regularly / 30 workshops a year	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	Max 15
UOM	MT	GameJams: designing and developing	Practice performed by the partner /	University of Malta Campus, Institute of Digital	Gamejams typically last 2-3 days.	May, June, July, September 2019	questionnaire surveys	Game Jam Events are open and may host

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
		digital games (or Game Design and Development Workshops)	immediately accessible by the partner for research purposes Local workshops can be organised as an initiative of the IDG, UoM.	Games labs and facilities	Game design and development workshops could be adjusted to a few hours workshops (e.g. 3 or 5 hours).	May, June, July 2020	individual interviews group interviews/focus groups discussions observations of activity	hundreds of participants. A workshop aiming to younger creators could possibly host up to 30-50 participants.
UOM	MT	Playing & Testing Digital Games	Practice performed by the partner / immediately accessible by the partner for research purposes Local playtesting and workshop sessions can be organised as an initiative of the IDG, UOM.	University of Malta Campus, Institute of Digital Games labs and facilities. Other possible venues include outreach activities such as local science fairs (Science in the City, Note Bianca), visits to local schools and colleges as well as coordinated actions with the Ministry of Education and Employment in	The playtesting events typical last up to 5 hours.	May, June, July, September 2019 May, June, July 2020	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity Learning analytics involving advanced state-of-the-art computer science	Each event can host up to 25 participants.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
				Malta.			(e.g. AI, affective computing) measuring qualities of the interaction with the digital games and learning outcomes (only possible in games with full control of the interaction and with already installed game logging)	
DFC	ES	Lab I CAN	Practice performed by the partner / immediately accessible by the partner for research purposes Labs I CAN are developed by DFC Spain's own practitioners, so we have immediate	Labs I CAN are carried out all over Spain, in any organization, school, institution, university, association, foundation, NGO, vocational training center, etc., which is interested in experiencing the DFC	Labs I CAN last 12 hours, where participants experience the complete process based on the DFC methodology. They learn, put what's learnt into practice, and plan for the future implementation of the methodology in their own field.	No restrictions	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of	Each Lab I CAN is designed for 10-25 participants. Total number of participants for the complete empirical research is still to be decided.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			access to all information for research purposes.	methodology.			intensive self-reflective participatory research	
DFC	ES	Lab WE CAN	Practice performed by the partner / immediately accessible by the partner for research purposes Labs WE CAN are developed by DFC Spain's own practitioners, so we have immediate access to all information for research purposes.	Labs WE CAN are carried out all over Spain, in any organization, school, institution, university, association, foundation, NGO, vocational training center, etc., which is interested in experiencing the DFC methodology and has already experienced a Lab I CAN.	Labs WE CAN last 12 hours, where participants go deeper into the process based on the DFC methodology. They learn, put what's learnt into practice, and plan for the future implementation of the methodology in their own field.	No restrictions	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	Each Lab WE CAN is designed for 10-25 participants. Total number of participants for the complete empirical research is still to be decided.
DFC	ES	Workshop I CAN	Practice performed by the partner / immediately accessible by the partner for	Workshops are carried out all over Spain, in any organization, school, institution,	Workshops last 2-4 hours, where participants get a glimpse of the DFC methodology.	No restrictions	questionnaire surveys individual interviews	Each workshop is designed for 15-30 participants, but can be adapted for larger numbers.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			research purposes The workshops I CAN are developed by DFC Spain's own practitioners, so we have immediate access to all information for research purposes.	university, association, foundation, NGO, vocational training center, etc., which is interested in experiencing the DFC methodology.			group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	Total number of participants for the complete empirical research is still to be decided.
OVOS	AT	[To be defined in deliverable D1.2]						
KCL	UK	The Invention Rooms, Imperial College London	Practice considered particularly interesting for COMnPLAY SCIENCE, but access to it needs to be agreed with its 'owners'	UK, West London, Imperial College	Drop-in (one offs, or on a regular basis) Planned workshops Longer programmes (once a week for several weeks)	Organisers are aware of the time periods which are interesting to the project and are happy to liaise with respect to what is possible.	We have indicated possible research methods (questionnaire surveys, individual interviews, group interviews/focus groups discussions, observations of	Numbers to be determined.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			Colleagues from the Invention Rooms are keen to explore a research relationship with COMnPLAY SCIENCE.				activity, other forms of intensive self-reflective participatory research) in the communication with the organisers.	
		Maker space within Science Gallery London	Practice performed by the partner / immediately accessible by the partner for research purposes In theory happy to be involved in the research but data collection is dependent on timings of programmes.	Science Gallery London, King's College London, London	Maker space sessions (could be all day, could be for a couple of hours)	Considering collecting data in first stage only at this point	questionnaire surveys individual interviews observations of activity	To be confirmed
SMG	UK	NUSTEM	Practice considered particularly interesting for COMnPLAY	Newcastle, North East England	Family programmes tend to be five weeks. They also run summer schools over the school holiday period.	Ongoing initiative however specific programme offerings change. Would have to	questionnaire surveys individual interviews	Family workshops tend to be classroom size workshops (~30 young

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			SCIENCE, but access to it needs to be agreed with its 'owners' Practice based at Northumbria University in the North East of England. Have professional relationship with the practice leaders but would need to check with them for access			check what exactly would be being delivered in the periods which are interesting to the project.	observations of activity	people). However their current partnerships are with 30 schools
SMG	UK	CoderDojo	Practice performed by the partner / immediately accessible by the partner for research purposes Practice considered	Worldwide	The Museum's sessions are currently 1 hour long, run a couple of times a day, once a month	Ongoing initiative	questionnaire surveys individual interviews group interviews/focus groups discussions	Each session at Science Museum currently holds 30 participants (excluding adults) however we have no control over whether they come to more than one session

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			particularly interesting for COMnPLAY SCIENCE, but access to it needs to be agreed with its 'owners' CoderDojo isn't a Science Museum initiative however it does occur at the Museum and is advertised through our channels and supported by our staff. We would need to double check with the organization whether they're happy to be involved.				observations of activity other forms of intensive self-reflective participatory research	or are repeat participants. If wanting to tap into the initiative as a whole they currently estimate 58,000 young people with help from 12,000 volunteers in 100 countries
SMG	UK	LEGOTinkering	Practice performed by the partner /	Global however pilots are at the Science Museum	Activities should take 30min in a formal setting	Currently in pilot phase. Next phase will be early next	questionnaire surveys	Pilots will be at the Museum during

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			immediately accessible by the partner for research purposes SMG are currently helping with the piloting of the activities			year where more info will become available.	individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research	weekends, estimate classroom size (~30) each workshop
SMG	UK	MakerClub (Brighton)	Practice considered particularly interesting for COMnPLAY SCIENCE, but access to it needs to be agreed with its 'owners' Currently SMG is in no way	Brighton primarily however also work across other locations in England	Year 'course', once a week	Ongoing initiative	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity	Last year they were working across 6 locations with 300 kids a week. 65% stayed for 12 months.

Partner	Country	Practices considered for the case studies	Practice 'ownership' and accessibility	Place of implementation	Typical duration of the activities	Time of implementation, time restrictions	Access and possible empirical research	Possible number(s) of participants
			affiliated.					
SMG	UK	Wonderlab	Practice performed by the partner / immediately accessible by the partner for research purposes Galleries developed and on SMG premises	Science Museum London & National Science and Media Museum Bradford	Depends on the group, no fixed time, however average dwell times for a visit are 1-2 hours at both sites	Only open during Museum opening times	questionnaire surveys individual interviews group interviews/focus groups discussions observations of activity other forms of intensive self-reflective participatory research SMG have conducted summative evaluations of both galleries and continue to track visitors with ticketing info and exit surveys.	Annual visitors to both Wonderlabs are 100,000+ (including school groups)

3.1.7 A note on data management

All research data and results produced through the activities foreseen in this conceptual and methodological framework will be managed in accordance with the provisions of the Grant Agreement on open access to research data and scientific publications, as well as the relevant strategy and methodology that the consortium will develop and present in deliverable D5.2 'Data Management Plan', which is due M6 (end November). This plan will provide answers to questions such as what data will be collected or generated, what standards will be used, how metadata will be generated, what data will be exploited, what data will be shared or made open, how data will be curated and preserved, etc. Relevant work is currently in progress in the context of Task 5.3 'Data protection'. The central concepts and provisions regarding open access to scientific publications and to research data are summarised below.

3.1.7.1 Open access to scientific publications

In particular it is noted that, as the Grant Agreement stipulates (Article 29.2), the consortium will ensure open access, i.e. free of charge online access for any user, to all peer-reviewed scientific publications relating to the results of the research described in the present conceptual and methodological framework.

More specifically, as soon as possible and at the latest on publication, the consortium members will deposit a machine-readable electronic copy of the published version or final peer-reviewed manuscript accepted for publication in a repository for scientific publications – at a minimum, by giving free online access to preprints of the scientific publications at NTNU's open access repository. Moreover, the consortium members will aim to deposit at the same time the research data needed to validate the results presented in the deposited scientific publications. The consortium will ensure open access to the deposited publication, via the repository, at the latest on publication, if an electronic version is available for free via the publisher, or within six months of publication in any other case. Finally, the consortium will also ensure open access, via the repository, to the bibliographic metadata that identify the deposited publication.

3.1.7.2 Open access to research data

In accordance with the Grant Agreement (Article 29.3) and with regard to the digital research data generated during the project, the consortium will deposit such data in a research data repository taking measures to make it possible for third parties, free of charge, to access, mine, exploit, reproduce and disseminate the data, including any associated metadata, needed to validate the results presented in scientific publications, providing also information via the repository about tools and instruments at the disposal of the consortium which are necessary for validating the results (and, where possible, access to the tools and instruments themselves). In all this, of course, all measures foreseen in the Grant Agreement for the protection of results, confidentiality, security, and personal data protection will apply.

Nevertheless, if the consortium decides that, as an exception, it will not be able to provide open access to specific parts of their research data due to the risk of jeopardising the achievement of the project objectives through making those specific parts of the research data openly accessible, such reasons will be explained in deliverable D5.2 'Data Management Plan'(M6).

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ANNEX A: TEMPLATE FOR THE IDENTIFICATION OF THE CONSORTIUM'S OWN PRACTICES

Consortium Partner:

Contribution to the identification of practices

Please fill in separately for each of the practices you are contributing.

Name/Title of the practice:

A) Practice identity

Participant age range:

COMnPLAY SCIENCE wide areas covered

Please mark the area mainly covered by the practice. If needed, you can mark more than one area.

[ ] Coding

[ ] Making

[ ] Playful activity

Please explain by describing the practice in a few words (who, why, what, how):

…

In your short description above please refer to how the practice may particularly relate to any of the following keywords:

- *computer education, computational thinking, robotics, etc.*
- *maker movement, makerspaces, digital fabrication, FabLab, etc.*
- *game-based learning (learning content and processes incorporated in gameplay), learning through play, etc.*
- *problem-based learning, problem-setting and solving*
- *project-based learning*
- *collaborative learning*
- *design thinking*
- *critical thinking*
- *curiosity, exploration*
- *imagination, creativity, creative thinking*
- *joy, fun, playfulness vs. serious learning activity*
- *engagement and personal investment in learning*
- *addressing real-life challenges*
- *families, communities*

Formality of the learning space(s)

Please mark one (or more, if necessary) of the three that best matches the characteristics of the learning space(s) in which this practice occurs.

[ ] Formal learning spaces

- planned activities, organised and structured environment
- explicitly designated as learning in terms of objectives, time, resources, support
- intentional from the learner's point of view
- leading to validation/certification

[ ] Non-formal learning space

- planned activities, organised and structured environment
- not always explicitly designated as learning in terms of objectives, time, resources, support, but containing an important learning element

- intentional from the learner's point of view

[ ] Informal learning space

- learning resulting from daily activities related to work, family or leisure
- not organised or structured in terms of objectives, time, resources, support
- mostly unintentional from the learner's point of view

Please mark any of the following that match the learning space(s) in which this practice occurs

[ ] Classrooms, labs, but possibly also out-of-school/university formal learning spaces, etc.

[ ] Museums, science centres, outreach centres, libraries, zoos, etc.

[ ] Community labs, FabLabs, etc.

[ ] Fairs, contests, challenges, etc.

[ ] Everyday life (e.g. personal hobbies, gaming, etc., etc.).

Please explain/describe in a few words how the practice relates to the concepts of formal/non-formal/informal learning spaces:

…

Link to science education

[ ] The practice is explicitly linked to STEM education, and specifically:

[ ] Science

[ ] Technology

[ ] Engineering

[ ] Maths

[ ] The practice is not intentionally meant as science learning activity, science learning is a by-product

Please explain in a few words:

…

B) Practicalities of implementation for the purposes of empirical research

Practice 'ownership' and accessibility

[ ] Practice performed by the partner, or in any way immediately accessible by the partner for research purposes

[ ] Practice considered particularly interesting for COMnPLAY SCIENCE, but access to it needs to be agreed with its 'owners'

Please explain briefly:

…

Place of implementation (country/area/institution…):

…

Typical duration of the activities (e.g. length of a full cycle, etc – please explain):

…

Time of implementation, time restrictions etc. *Note that the empirical research will be conducted in two major stages: the first, nine-month exploratory stage (M9-M17, i.e.*

February-October 2019), and the second, ten-month insight stage (M18-M27, November 2019-August 2020):

…

Project research team's access to learners for the empirical research / practical possibility of conducting:

[ ] questionnaire surveys

[ ] individual interviews

[ ] group interviews/focus groups discussions

[ ] observations of activity

[ ] other forms of intensive self-reflective participatory research

Please explain and estimate **possible number(s) of participants**:

…