COM n PLAY
SCIENCE

# PROJECT DELIVERABLE

# D2.1. IDENTIFIED PRACTICES AND RESEARCH SAMPLE

Dissemination level: public

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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 classrooms
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**Overview**
The project aims to help Europe better understand the new ways in which non-formal and 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 non-formal and 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 non-formal and informal science learning has on formal science education, traditional non-formal and 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 non-formal and informal science learning.
- Numerous public events (workshops, training seminars, conferences, contests, fairs), often combined with training activities (winter and summer schools).

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| 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
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ResearchGate: https://www.researchgate.net/project/CoM-n-Play-Science

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# Introduction

One of the main objectives of COMnPLAY-Science is to identify and pool several and diverse existing coding, making and play-based practices taking place outside formal science classrooms which nevertheless appear to bear some promise for informal science learning. To do so, the consortium both drew on its own activities and background, and invited practitioners from all participating countries and across Europe to contribute their practices, through an open survey. The practices identified and pooled include 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, Responsible Research and Innovation (RRI), and science capital.

Then COMnPLAY-Science selected coding, making and play practices that they can be subsequently analysed in the context of the in-depth research conducted by the project thought empirical research. The consortium based this selection on the characteristics and particularities of the identified practices, including their nature and their appropriateness and availability for in-depth learner-centred research, and proceeds to organize the practicalities of their involvement in the research. The selection was also based on the fact that the consortium should include a variety of diverse coding, making, and play practices, including such activities intentionally organized to achieve aims overtly related to informal science learning (e.g. in science centres), and activities that are not originally intended as science learning activities and which take place both in organized contexts (e.g., fabrication labs, coding labs) and independently in everyday life (e.g. personal hobbies, gaming, fairs and private projects).

The Deliverable 2.1 consists of two main parts. Section A introduces the study for the identification and pooling of practices, while Section B introduces the selection of practices that serves as the research sample for the in-depth case studies in the next phase of the project.

# SECTION A - IDENTIFICATION AND POOLING OF PRACTICES

## 1. Introduction

The herein introduced exploratory research is built on the COMnPLAY SCIENCE project Task 2.1, which set out to identify and pool several and diverse existing coding, making and play-based practices taking place outside formal science classrooms. To this end, the consortium both drew on its own activities and background, and identified, invited and motivated practitioners from all participating countries and across Europe to contribute their practices to the project. This was achieved through concerted communication efforts and specifically designed and deployed outward-looking campaigns, in close synergy with the dissemination and exploitation efforts of the project. The practices identified and pooled include 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, Responsible Research and Innovation (RRI), and science capital. Work in Task 2.1 was coordinated by the TUE, with all project partners closely collaborating and contributing with their expertise.

To tackle the problem of pooling practices, after a thorough consideration of the possible research strategies involving their methodological aspects and the general applicability across several European countries, the consortium decided to adopt a quantitative approach to the collection and analysis of the dataset. A survey instrument was designed that included many open-ended questions, this way providing an opportunity to explore as much as possible under the given circumstances about the ongoing practices across Europe. Additionally, semi-structured interviews were conducted with practitioners focusing on their personal story: their background, driving motives, and issues they are facing as informal and non-formal science education practitioners. These interviews informed the process of the selection of practices for the in-depth studies. In this document, we report on the identification and pooling of practices based on the analysis of the data collected through the survey.

## 2. Theoretical Background

There are a limited number of studies in science education research that link specifically to the practices of contemporary informal and non-formal science learning practices. The herein introduced study, as the initial part of the COMnPLAY SCIENCE project, aimed to map the current state of these practices across Europe to have a general overview of them.

### 2.1 Formal, informal and non-formal learning

Before presenting the survey, it is important to introduce our understanding of informal and non-formal learning and to address the main difference between those and formal education. The Council of Europe defines these concepts as follows[1]: "Educational systems exist to

[1] https://www.coe.int/en/web/lang-migrants/formal-non-formal-and-informal-learning

promote *formal learning*, which follows a syllabus and is intentional in the sense that learning is the goal of all the activities learners engage in. Learning outcomes are measured by tests and other forms of assessment." On the other hand, "*Non-formal learning* takes place outside formal learning environments but within some kind of organisational framework. It arises from the learner's conscious decision to master a particular activity, skill or area of knowledge and is thus the result of intentional effort. But it need not follow a formal syllabus or be governed by external accreditation and assessment. Non-formal learning typically takes place in community settings (...). Some non-formal learning arrangements become increasingly formal as learners become more proficient; one thinks, for example, of graded exams in music and other performing arts." And "*Informal learning* takes place outside schools and colleges and arises from the learner's involvement in activities that are not undertaken with a learning purpose in mind. Informal learning is involuntary and an inescapable part of daily life; for that reason, it is sometimes called *experiential learning*. Learning that is formal or non-formal is partly intentional and partly incidental: when we consciously pursue any learning target we cannot help learning things that are not part of that target. Informal learning, however, is exclusively incidental." We adopt these definitions during our research.

## 2.2 Previous studies

There is little earlier research on informal and non-formal learning practices. As far as we know our study is the first of its kind with regards to content and volume. The study of Falk and colleagues [5] examined the UK science education by taking a systemic perspective. In their exploratory research, they collected nation-wide information on science education with a focus on the community and the interconnectivity of its identified sectors. Their study included data from 169 science educator respondents from across the entire UK. They used a web-based questionnaire to collect information which they analysed based on: target audience and educational goals, sector interaction and sector independence. Their findings suggest little variability in the distribution of audiences across sectors, however, with a focus on children and youth (age range of 5-19) and much less attention to adults. Among the educational goals (rank-ordered from a predetermined list), the most frequently mentioned aspects were to *make science enjoyable and interesting* (91%) and *inspire a general interest in and engagement with science* (89%). Among the least frequently mentioned educational goals were to *prepare participants for further science education or careers* (27%), *encourage further learning in non-science subjects* (23%) and *prepare participants for non-science careers* (12%). Their study of sector interconnectivity leads to the conclusion that while the science education community is highly interconnected within individual sectors, the between sectors collaboration is very limited. They state that "rather than conceptualizing the public science education system as a schooling alone (pre-K, K-12, and postsecondary formal education), a system-wide approach recognizes that formal education entities are critical and necessary components but not sufficient; they alone do not constitute the whole system. In a community-wide science education system, the vast array of informal entities such as science centers, digital media, after-school programs, and so on, need also to be included as mounting evidence now shows that these entities equally support the public's science education." (p. 146)

## 2.3 Science Capital

In an attempt to address science education more holistically, the concept of Science Capital [2, 14] provides policy makers and practitioners with a useful framework to help understand what shapes young people's engagement with and potential resistance to science, and their participation and learning in both formal and informal science learning spaces. 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 one knows about science, how one thinks and one's attitudes towards science, what one does, and who one knows. The bag is dynamic and not fixed – one can add and build science capital as one goes through life.

The concept of science capital draws on the work of French sociologist Pierre Bourdieu, in particular his studies focusing on the reproduction of social inequalities in society [3]. 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 a lens through which to understand how individuals' participation and engagement in different making, coding and play activities may vary. The concept of science capital helps us explain why some young people are more likely than others to participate in science. 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. 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 one does, who one knows, and what one's family values are. 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-informed teaching approach is about starting from personal, lived, experiences of learners and building upwards, gradually linking such experiences to canonical science. Clearly, a young person's science capital derives as much from the conversations, activities and experiences that happen outside of school as it does from the experiences in science lessons. In sum, the combined contribution of informal and non-formal science learning spaces and experiences play a significant role in shaping science capital.

## 2.4 Intrinsic motivation and engagement

Intrinsic motivation is "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn." ([11] p. 70). Developmental psychologists acknowledge that children are especially and generally driven by intrinsic motivation during their physical and mental development. They are curious, explorative, active and playful, even when there is no specific reward available. Children enjoy challenges and exploring the world around them [11]. However, certain social-contextual conditions are needed to trigger intrinsic motivation. According to Malone and Lepper [9, 10] intrinsic motivation can be evoked by the optimal levels of challenge, curiosity and fantasy. According to the self-determination theory (SDT)[2] of Ryan and Deci [11], the conditions that trigger intrinsic motivation are organised around the satisfaction of three psychological needs: competence, autonomy and relatedness. Based on the cognitive evaluation theory [13] (which is a sub-theory of self-determination theory) as long as the psychological need for feeling competent is present, positively challenging activities that promote greater perceived competence can evoke intrinsic motivation because they satisfy the individual's need for feeling competent. Intrinsic motivation therefore has a strong effect on learning in general, and plays a key role in case of informal and non-formal science learning activities.

Besides intrinsic motivation, engagement has a strong effect on learning as well. The main aims of informal and non-formal learning activities in the UK study discussed above [5], were to make science interesting and enjoyable (i.e. building on children's curiosity and based on the aforementioned theories and particularly those associated with intrinsic motivation) and to support children to become engaged with science.  Engagement is generally categorised by scientist into three types: behavioural, emotional and cognitive engagement [6]. In the educational context often all three are discussed. "Behavioral engagement refers to effort and persistence and is distinct from cognitive engagement in that the emphasis is on the amount or quantity of engagement rather than the quality of thought or type of engagement. In contrast, cognitive engagement refers to the quality of one's thinking in terms of cognitive strategies (e.g., elaboration, rehearsal), metacognitive strategy use, and self-regulated learning." ([8] p. 113). Besides, emotional, or affective engagement is often described in terms of eagerness, interest, enjoyment and enthusiasm [7]. The above referred study [5] revealed that informal and non-formal science learning activities are aiming to engage participants in all three levels. Despite these results being based on UK data, we expect that they will be mirrored in our European study results.

# 3. Methods

## 3.1 Development of the survey

For the structural development of the survey, the conceptual framework described in the COMnPLAY SCIENCE project deliverable D1.1 was taken as a starting point. The referred document defines the dimensions of the conceptual framework with the following aspects: a) identity and type of activities; and b) learning and science education concepts utilised (complementary learning concepts, social aspects, links to coding, making, play activities to science education / STEM / STEAM.) Additionally, it also defines the dimensions of the methodological framework for a) the methodological design; and b) the methodological tools. Besides the dimensions of D1.1, the published survey of the aforementioned study [5] was investigated for further aligning concepts.

The main structure and the content of the survey were discussed in several iterations with the whole consortium, with special regards to the field experts. The final version of the survey was digitised and publicly shared through a secure server with free anonymous access

[2] "SDT is an approach to human motivation and personality that uses traditional empirical methods while employing an organismic metatheory that highlights the importance of humans' evolved inner resources for personality development and behavioural self-regulation" ([12] p. 68)

through a link. The language of the survey was English, however, responses for the open-ended questions could be provided in the native languages of the respondents. Due to special data protection regulations, the German data were collected in German language on a German server and were later translated to English and merged with the main data set. The survey consisted of 35 questions, 7 of which concerned demographic information. From the remaining 28 questions, which investigated the ongoing activities, 10 were open-ended. An offline version of the survey is presented in Appendix A

## 3.2 Statistical analysis

Given the exploratory nature of the study, we mainly report descriptive statistics, thus preferences and frequencies. For the quantitative survey questions, simple frequency analysis was applied. For the qualitative survey questions, an inductive coding approach was adopted: the main content was subtracted from each of the collected responses and consequently, a code was assigned to those.

## 3.3 Data

Data were collected from 158 practitioners across eleven European countries via an online form applying convenience sampling method.

## 3.4 Software

For the data analysis, the IBM SPSS Statistics v25 was used.

# 4. Results

We introduce our Europe-wide study results in the following sections: demographics of the respondent practitioners; description of the practices, their main goals and relation to formal education; the place and prevalence of the activities; the target audience; young people's participation and favoured aspects of the activities; and strength and weaknesses of the activities.

## 4.1 Demographics of the respondent practitioners

Two of the 158 respondents didn’t consent to using their data in our report, therefore they were excluded from the analysis. Consequently, the data of 156 respondents were used. The response rate per country by gender is presented in Table 1.

**Table 1. Proportional table of respondents per country by gender.**

| Country | Female | Male | Other | Prefer not to say | *Total* |
|---|---|---|---|---|---|
| **Austria** | 3.8% | 5.8% | 0.0% | 1.3% | *10.9% (17)* |
| **Finland** | 4.5% | 7.7% | 0.0% | 0.6% | *12.8% (20)* |
| **Germany** | 10.9% | 5.2% | 0.0% | 0.6% | *17.3% (27)* |
| **Greece** | 3.8% | 3.8% | 1.3% | 0.0% | *10.0% (14)* |
| **Malta** | 2.6% | 1.9% | 0.0% | 0.0% | *4.5% (7)* |
| **Netherlands** | 1.3% | 3.2% | 0.0% | 0.0% | *4.5% (7)* |
| **Norway** | 2.6% | 9.6% | 0.0% | 0.0% | *12.2% (19)* |
| **Spain** | 6.4% | 5.8% | 0.0% | 0.0% | *12.2% (19)* |
| **Sweden** | 1.9% | 3.2% | 0.0% | 0.0% | *5.1% (8)* |
| **United Kingdom** | 4.5% | 4.5% | 0.0% | 0.0% | *9.0% (14)* |
| **Other/missing** | 1.3% | 1.3% | 0.0% | 0.0% | *2.6% (4)* |
| ***Total*** | *43.6% (68)* | *53.2% (83)* | *1.3% (2)* | *2.6% (4)* | *100% (156)* |

Regarding the occupational properties, 77.6 % of the respondents work as an employee and 21.2 % of them work as a volunteer. Among all respondents we found that 18.6 % is self-employed and 78.2 % is a member of an organisation.

The average time spent on the activities per week varied from 0 to 60 hours. However, 12.2% of the respondents do not work on a fixed weekly basis, either because the average time spent on the activities varies a lot or because it is a project that occurs within a certain period of time. Regarding the others, 46.8% of all respondents work a maximum of 10 hours on the activities, 14.1% of the them work between 10 and 20 hours, 7% of them works between 20 and 30 hours, and 13.5% of them work in full-time (35 to 42 hours). 2.5% of the respondents spend more than 42 hours a week on the activities.

In sum, our sample consists of 156 participants, who run informal and non-formal learning activities in eleven European countries. The gender proportion of males and females is 53.2% and 43.6% respectively with the majority of our participants working as an employee of an organisation (77.6%) - mostly (67.9%) part-time.

## 4.2 Types of practices, main goals, relation to formal education

As the declared aim of the presented exploratory study was to investigate the current state of informal and non-formal science learning activities with special regards to coding, making and play activities, we asked the practitioners to report on this matter. Based on the collected data, in 69.9% of the activities a computer is used and in 67.9% of those activities, the young people are engaged in making activities. The 57.7% of the activities are explicitly designed to be playful, while 56.4% of them involve coding. 16.6% of the respondents indicated that something else important is happening besides the aforementioned options, from which 5.1% reported that young people participate in experiments and 1.3% reported that young people design during the activity.

We also asked the practitioners to select from a list the option(s) that describe the best the ongoing activity. Based on our data, we can conclude that the activities most frequently focus on creative thinking (60.9%) and involve project or task-based learning (55.1%), while discovery-learning (51.3%), collaborative-learning (49.4%) and problem-based learning (42.3%) are also in focus. Based on our sample much less focus is on critical-thinking (26.3%), design-based learning (25.0%), real-life challenges (25.0%) and the involvement of families/communities (19.9%).

Another objective of the study was to gain a general overview of what informal and non-formal educators aim to achieve with their activities. To approach this question, we adopted the framework of the National Science Foundation [1] for evaluating the impact of informal science education projects. Our findings indicate that most frequently the activities aim to evoke interest in young people about a specific topic and get them engaged (39.7%), while raising awareness, knowledge and understanding (25.6%) and skill improvement (21.2%) also were found to be important. Aiming for an attitude or behaviour change (5.8% and 0.6% respectively) was less frequently reported. Only 7% of all respondents indicated the 'other' option, from which improving self-efficacy (1.9%) and scientific self-image (1.3%) appeared repeatedly.

We also wanted to understand how these informal and non-formal activities relate to formal education, whether there is any explicit learning goal or intentional curriculum material coverage. We found that 51.3% of the collected activities have explicit learning objectives which are explicitly linked to school curricula in 35.3% of the collected responses. Additionally, approximately one-third (34.0%) of all collected activities are designed to help young people attain qualifications.

Among the described explicit learning objectives, we found several emerging topics. Raising awareness of certain topics, bringing science closer to young people, coding, computational thinking, creative thinking, critical thinking, designing, experimenting, gathering knowledge on certain topics, making, problem-solving, programming and collaborative working were the most frequent ones. Having these responses among the explicit learning goals suggest that the collected informal and non-formal science learning activities do not simply apply the aforementioned methods but they clearly aim to teach their application to the participants.

Regarding the most often covered curricular subjects, technology (66.7%), computer science (55.8%), physics (50.6%), mathematics (48.7%) and design (41.0%) are the most favoured ones followed by art (34.6%), biology (28.2%), chemistry (27.6%), geography (17.3%), humanities (14.1) and literature (7.7%).

## 4.3 Context

To gain an insight of the context of the on-going activities, we asked the practitioners about the location and the frequency of the activities. Respondents reported that 40.3% of the collected activities are based in classrooms or other formal learning spaces, whereas 26.9% are taking place in museums, science centres, outreach centres, libraries/zoos and 15.4% in community labs or Fablabs. Having the activities based in fairs/contests/challenges (3.2%), everyday life (e.g. hobbies, gaming; 1,9%) and in the outdoors (0.6%) were the least reported. Among the 'other' option, home appeared as base for the activities (1.3%), while 7.8% of the respondents said that their activities occur across the sites listed and 1.9% said that their activity could occur anywhere.

Regarding the frequency of the activities, we can conclude that the collected activities are mostly single-occasion activities (40.3%) or once-a-week activities (31.4%), while the minority of the activities happen multiple times per week (3.8%) or once per month (5.1%). Additionally, 18% of the collected activities do not fit in the given frequency options. Among the other responses, we found once in every two weeks (1.9%) to be the most frequent one, but the variation was significant. Some respondents report that the activity is held during a (summer) camp, for 5 days in a row.

## 4.4 Target audience

Multiple options were allowed for indicating the target audience. The analysis of the target audience revealed that 67.3% of the activities target the 7-12 years age group, while 58.9% of the collected practices targets 13-17/18 years youth. The least targeted age groups were the 4-6 years old children (15.2%) and the 17/18-21 years old young adults (20.3%).

Since women are generally underrepresented in scientific fields [4], we wanted to know more about girls' participation in the activities in our survey. We therefore asked the respondents to estimate the proportion of girls/females among their participants. Based on their estimation, our findings suggest that in almost half (46.8%) of the activities, the gender proportion of girls is lower than 50%. At 32.7% of the surveyed activities, the respondents estimated the gender proportion of girls and boys to be equal, while only in 7% of the activities the gender proportion of girls were estimated to be above 50%. Some of the respondents reported a varying proportion depending on the type of school the pupils attend (2.4%), the theme of the activities (1.2%), or the place where the activities take place (0.6%).

We also investigated whether the activities are specifically designed for any kind of (minority) population besides the age groups. We found that the majority (72.4%) of the surveyed activities are not tailored to any specific groups. When tailored, specific age groups (7.2%) are mentioned with young people with low socio-economical and/or migration background (3.6%), young people with disabilities or special needs (3%), and girls (1,3%). However, it has to be mentioned, that the range of the specific groups was diverse, including, for example, even activities for young offenders (0.6%).

## 4.5 Young people's participation

It was considered important to get an overview of young people’s participation and favoured aspects of the activities. Unfortunately, in this study it was not possible to directly ask young people, therefore we asked the survey respondents to report on this matter based on their personal experience. Regarding the question 'Which aspect of the activity young people generally appreciate the most?' the most frequently indicated options were 'Making something by themselves' (73.1%), 'Doing something new' (68.6%), and 'Doing something that isn't 'school-like'' (55.1%). The least often indicated reasons were 'Having freedom to choose what they do' (30.8%), 'Hanging out with their friend' (19.9%) and 'Meeting new people' (14.7%). Among the remaining options (8.3%), aspects that have been reported included 'playing and having fun' along with 'spending time with family' and 'children doing/making something they like. Social connections (with family, mentor, or others) appeared to be an important aspect as well.

We also asked the practitioners' opinion regarding who initiates participation in the activity. We report the resulting numbers in Table 2. and we focused our interpretation on the 'often' response category. Based on the percentages reported in Table 2, we can conclude that young people's participation is estimated to be in 41% of the surveyed activities self-directed. In the rest of the cases, parents and teachers have a strong role in initiating young people's participation in the surveyed activities. As these numbers are based on the practitioners' interpretations, they are exposed to a degree of bias which has to be accounted for when interpreting the dataset.

**Table 2. Who initiates the participation in the activity?**

| | Never | Rarely | Sometimes | Often | Always |
|---|---|---|---|---|---|
| young people come voluntarily (self-directed) | 2.6% | 11.5% | 20.5% | 41.0% | 20.5% |
| parents decide about participation | 9.6% | 23.7% | 24.4% | 31.4% | 6.4% |
| teachers/educators decide about participation | 32.7% | 16.7% | 16.0% | 23.1% | 9.6% |

Based on the responses we can conclude that young people had a relatively free choice regarding their participation. In 41.6% of the collected cases the practitioners provided young people with a list of activity options which they could choose from. In 25.0% of the cases young people were free to choose to do whatever they want, and in 31.4% of the activities young people are provided with one option at a time.

## 4.6 Strengths and weaknesses of the practices

We wanted to investigate the strengths of the activities from a more subjective point of view. Therefore, via an open-ended question we asked our respondents to report on in which ways they find the activities successful. We analysed the responses with an inductive coding approach: the main content (i.e. aspects) of each response was subtracted, those aspects were categorised into topics and consequently, a code was assigned to each topic. From a very vivid and broad palette of responses here we introduce a collection of the most frequently emerged topics. The absolute top-ranking strengths of the collected practices were to evoke participants' interest and to engage them. Providing the possibility to learn new technologies and the accessibility of the activities were frequently mentioned strengths, too. Additionally, respondents found that their activity is successful in terms of providing participants choices during the activity (autonomy), facilitating perception change about e.g. conventionally unpopular topics, promoting collaborative work and creative thinking, making education and learning fun, supporting change in self-perception (e.g. confidence) and to help to prepare for the future by providing career support. An interesting observation is that some countries mention success in relation to acquiring knowledge and skills, while others report more frequently on the playfulness and social aspects of the activity. Whether it is due to a sampling bias or it is a sign of cultural difference could be investigated in further studies.

Besides the successful aspects, we were also interested in the possible improvement points and weaknesses of the activities. We asked our respondents via and open-ended question and followed the above-described protocol for coding and analysing the data. Here again, we got a very colourful list, out of which the most frequently emerging topics are presented. Practitioners reported most frequently on facing financial and time-related constraints along with experiencing difficulties in terms of outreach and motivating future participants (e.g. covering a wider age-range, getting parents involved etc.). Others report on weaknesses in relation with the equipment (e.g. hardware/software problems, quality or quantity issues) and the actual content of the activities (e.g. could be broader, longer, with more tools, be more creative, be more playful etc.) as possible improvement point. Some respondents reported staff shortage, dependency (e.g. on parents or organisers) and issues with premises (e.g. lack of sufficient space, sites are not separated well enough from each other).

# 5. Discussion

In this report, we introduced our Europe-wide exploratory study on informal and non-formal science learning practices and activities. The aim of the study was twofold: (1) to map the currently on-going activities and gain an overview of these, and (2) to collect practices which will form the basis for the selection of best practices for the in-depth studies in the next phase of the project.

We collected survey data from 158 informal and non-formal science-learning practitioners from eleven European countries and introduced the main findings. Since we applied a convenience sampling method, the generalizability of our results is limited. However, we propose that given the extent and volume of the study, these results provide a reliable indication of the current situation in Europe. The collected practices show a very broad range with regards to the content, target audience, approaches, main goals etc. including many combinations. Despite some emerging trends, it is not appropriate to generalise as we would risk losing valuable information about the uniqueness of the activities.

In the Introduction section, we presented the working definition of formal, informal and non-formal education. Based on our findings, we can conclude that the surveyed activities cover both informal and non-formal learning activities. The activities that have no declared learning goals were categorised as informal learning activities. Those that are taking place outside the school curriculum and have the definite aim to help participants acquire new knowledge were categorised as non-formal learning activities. In the collected data, each category takes up approximately half of the sample.

To illustrate a representative picture of the professionals who are engaged in this segment of science education, we can picture either a male or female adult who is an employee of an organisation and works part time on the activities. Having approximately equal number of males and females among the activity leaders is important from the perspective of building science capital, since having an available role-model (Who you know) makes the identification with the 'sciency' self-image easier. The activities are mainly taking place in a formal educational environment (e.g. school or university buildings) or at a non-formal science learning space (e.g. museums, science centres, community labs). Most of the activities are single-occasion activities. However, weekly activities are also frequent.

Regarding the target audience, our findings mirror the findings of Falk and colleagues [5] over the UK situation. That is, the majority of the surveyed activities targets either the 7-12 years age group and/or the 13-17/18 years age group. This is in accordance with the target audience of the in-depth studies in the next phase of the project. However, it should be noted that there is little emphasis on the younger, nursery-aged children despite this age range being a very curious, receptive and responsive period of cognitive development. Some of the activities target specific groups (e.g., young people with disabilities), however, these kinds of activities are rare. The majority of the activities are reaching out for the general audience.

Our findings suggest that girls are generally under-represented in the surveyed activities, with exception of a small fraction (7%) of the sample where girls are the majority. However, a promising one-third of the activities report gender equality among the participants and through the responses to the survey, it was noted several times that practitioners are aiming to reach gender balance.

Regarding the main interest of the project, two-thirds of the activities involve making activities, more than the half of the activities are intended to be playful, and coding activity appears in more than the 50% of them. Additionally, the majority of the activities cover the formal educational subjects of technology, computer science, physics and mathematics. We found that half of the collected activities have declared learning objectives, which are often (35.3%) linked explicitly to school curricula.

Our study results are in agreement with previous findings [5] with regards to the main aim of the activities. We found that encouraging young people to become interested in scientific topics and get engaged in the activity were the most frequently mentioned goals. This process builds on intrinsic motivation which is associated with discovery-based learning and opportunities for creative thinking.  Based on the report of the practitioners, young people are relatively free to have their own choice of activity to participate in (only at one-third of the activities is one option offered). Practitioners also reported that in their perception young people most appreciate the opportunity to make something by themselves and do something new that isn't ‘school-like’.

The most frequently reported strengths of the activities mirror the aforementioned main aims such as evoking participants' interest and engagement. Additionally, the activities were reported to be successful in terms of being accessible, familiarising participants with new technologies, facilitating perception change about less popular topics/science areas, providing participants with choices during the activities and increasing self-confidence. Among the possible improvement points the most pressing issues to address were difficulties associated with outreach, availability of finances, time, appropriate premises and staff. Intentions relating to improving the content of the activity were also mentioned frequently.

Evaluating the information we gathered, there is one crucial point to be further discussed. Namely that, based on the survey responses, one of the most cited reason for liking the activities was that they aren't 'school-like'. Taking a step further, this raises a serious question regarding what may be learnt from this research: if non-school-like is synonymous with enjoyment and participation, how might schools become more non-school-like? From our analyses we postulate that a key factor underlying the non-school-like preference may be the informal and non-formal approach to the material. More specifically, here we clearly see the tendency for hands-on learning let it be about a topic that young people have learned in the school. Given that children are generally curious and very sensory, giving them the possibility to get physically engaged and involved in the learning process makes it very attractive for them. Additionally, this type of learning makes the learning process feel indeed less school-like, since young people discover new information (knowledge) by themselves as well and are not only taught by a teacher.

To sum up, while looking at the informal and non-formal learning activities, there is a whole web of things that are building on each other. The activities are mainly intended to be playful and engaging, therefore young people's participation is often self-initiated. In case young people are obligated to attend, the activities still build on intrinsic motivation and aim to engage young people by introducing topics in a playful and interesting way. Once young people become engaged, they feel like their participation is of their own choice (even though they are brought there) and intrinsic motivation arises for staying in the loop that satisfies their need for enjoyment and competence. Additionally, young people are often able to take home their creations/artefacts, which adds up to the whole experience and functions as a reminder that learning science is fun.

# 6. Further work

Through the study introduced above, we gained a general insight into the on-going European informal and non-formal science learning activities. In the next phase of the project, we will explore in-depth the selected practices and increase our understanding of their particularities (methods, pedagogical approaches etc.) of introducing science to young people, with special regards to coding and making. Ultimately, with our increased knowledge we aim to facilitate and support positive change in formal science education at the European level.

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# 7. Appendix A: The survey

COM n PLAY SCIENCE

Informal- non-formal science learning practices inventory

Dear Participant,

You have been invited to share your knowledge and experience with us about informal and non-formal science learning practices. With the term of informal and non-formal science learning practices we refer to activities that aim to introduce science to children outside of the curriculum. We devote special attention to coding, making and playful activities, however, we don't restrict ourselves to these ones only.

The research is a part of the COMnPLAY SCIENCE project and is funded by the European Union. You can find more information at http://comnplayscience.eu/

We will treat your data anonymously according to GDPR.

Thank you for participating in our research,
COMnPLAY SCIENCE team

Declaration:

Hereby, the COMnPLAY SCIENCE project declares that the collected data will be stored safely, it will be handled anonymously and will not be given to any third parties not involved in the research project.

---

*Required

1. Hereby, I declare that I have been informed sufficiently, my participation is voluntarily and I give my consent to the COMnPLAY SCIENCE project to handle my responses and data according to the operative GDPR law.*
   - Yes
   - No
2. In which country do your informal and non-formal science learning activities take place?
   - Austria
   - Finland
   - Germany
   - Greece
   - Malta

- Netherlands
- Norway
- Spain
- Sweden
- United Kingdom
- Other:

3. Do you get paid for your work?
   - Yes
   - No, I am a volunteer
4. You participate in informal / non-formal science learning activities as a(n):
   - Independent worker / self employed
   - Member / employee / volunteer of an organisation
5. If you work for an organisation, could you please name it?

6. How many hours do you spend approximately on these activities?

*Per week. If other, please indicate*

7. Please could you indicate to which gender identity do you most identify?
   - Male
   - Female
   - Prefer not to say
   - Other:

8. We would like to know more about the ongoing informal and non-formal science learning practices across Europe. Please select one activity that you participate in or that you lead. The following questions targeting that specific activity. If you prefer, feel free to respond in your own language to the open-ended questions.

*Please write here the name of the activity*

9. Please give a brief description of what happens during the selected activity.

10. Please indicate whether the children
    - Use computers
    - Make stuff
    - Play games
    - Engage in playful activities
    - Code

- Other:

11. Please select up to THREE of the following terms that describes the best what happens during the activity
    - Problem-based learning
    - Project (or task)-based learning
    - Design-based learning
    - Collaborative-learning
    - Discovery-learning
    - Creative thinking
    - Critical thinking
    - Real-life challenges
    - Involving families/communities
12. What is the MAIN aim for this activity?
    - Awareness, knowledge or understanding (change in awareness, knowledge, understanding of a particular scientific topic, concept, phenomena, theory, or careers central to the project)
    - Engagement or interest (change in engagement/interest in a particular scientific topic, concept, phenomena, theory, or careers central to the project)
    - Attitude (change in attitude toward a particular scientific topic, concept, phenomena, theory, or careers central to the project or one's capabilities relative to these areas.)
    - Behaviour (change in behaviour related to the topic.)
    - Skills (Development and/or reinforcement of skills, either entirely new ones or the reinforcement, even practice, of developing skills (e.g. using microscopes or telescopes successfully).
    - Other:

13. In what ways is this activity successful in your opinion? What are its strong points?

14. In what ways could this activity be improved in your opinion? What are its weak points?

15. Is the activity designed to help young people attain qualifications?
    - Yes
    - No
16. Are there any explicit learning objectives?
    - Yes
    - No
17. If YES, could you please list those objectives?

18. Are the goals and objectives of the informal learning activity explicitly connected to school curricula?
    - Yes
    - No
    - I don't know
19. Please indicate which curricular subjects are covered during the activity (if any)
    - Technology
    - Computer science
    - Mathematics
    - Physics
    - Chemistry
    - Biology
    - Geography
    - Humanities
    - Literature
    - Arts
    - Design
20. Where is the learning activity based?
    - Classrooms, formal learning spaces, etc.
    - Community labs, FabLabs, etc.
    - Museums, science centres, outreach centres, libraries, zoos, etc.
    - Fairs, contests, challenges, etc.
    - Everyday life (e.g. personal hobbies, gaming, etc.).
    - In the outdoors
    - Other:

21. Please indicate the duration of the activity (in hours)

22. Could you please specify how often do you have the activities with the same group?
    - It is a single-occasion activity
    - Once a week
    - Multiple times per week
    - Once a month
    - Other:

23. In total, how many times do you meet with the same group?

24. What age group do you work with during the activity?
    - 4-6 years ('nursery')
    - 7-12 years ('primary')

- 13-17/18 years ('secondary')
- 17/18-21 years ('higher education')

25. Could you please estimate the percentage of girls/females participating in the activity?

26. Are the activities you are involved in tailored to any special specific group(s)?
- Yes
- No

27. If YES, could you please name and describe those group(s)?

28. To what extent do the participants chose their learning activity?
- They are free to choose to do whatever they want
- They are provided with a list of options which from which they can choose
- They are provided with one option at a time

29. Please indicate, in your opinion how often do

| | Never | Rarely | Some times | Often | Always |
|---|---|---|---|---|---|
| young people come voluntarily (self-directed) | | | | | |
| parents decide about participation | | | | | |
| teachers/educators decide about participation | | | | | |

30. Which aspects of the activity do you think young people appreciated the most? Please mark up to THREE options.
- Meeting new people
- Hanging out with their friends
- Making something by themselves
- Having freedom to choose what they do
- Doing something new
- Doing something that isn't 'school-like'
- Other:

31. Would you like to share with us any other comments?

32. Can you name any individuals or organizations who are engaged in informal / non-formal science learning practices, which you find inspiring or very original that other educators can learn from? (Please note that with informal and non-formal science learning practices we refer to activities that aim to introduce science to children outside of the curriculum.)

33. Please provide any comments you want about these individuals/organizations

34. We would like to thank you for your participation and valuable input. If you are happy for us to contact you again in the future to share summaries of our findings, news of local events, and eventually to be invited for further studies within the project, please provide us with your name and email address. We will treat this information in accordance to the GDPR and will not give it to any third party.
*Please write below your name and your email*

35. If you would like to have a copy of your answers, please make sure to print the form before you leave.

- Okay

Submit

# SECTION B - SELECTION OF PRACTICES - RESEARCH SAMPLE

## 1. Introduction

In the previous section we introduced the pooling of practices. In this section, we are introducing the selected *best practices* for the in-depth case-studies from those that were identified during the pooling process. This section is built on the COMnPLAY SCIENCE project Task 2.2, which focused on the selection of practices. In this task, the project carefully selected coding, making and play practices out of those identified and pooled, so that they can be subsequently analysed in the context of the in-depth research conducted by the project. The consortium analysed the characteristics and circumstances of each of the identified practices, including their nature and their appropriateness and availability for in-depth learner-centred research, and proceeded to organize the practicalities of their involvement in the research. The selection process made sure to include a variety of diverse coding, making, and play practices, including such activities intentionally organized to achieve aims overtly related to informal science learning (e.g. in science centres), and activities that are not originally intended as science learning activities and which take place both in organized contexts (e.g. fabrication labs, coding labs) and independently in everyday life (e.g. personal hobbies and private projects, gaming). Work in the Task was coordinated by NTNU, with all project partners closely collaborating and contributing from the perspective of their fields of expertise.

## 2. General description of the selected practices

The 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 further details see D1.1-Conceptual and Methodological Framework.

Hence, first we summarise our selection of practices in terms of their descriptive properties then in the following section we introduce the selected *best practices* for the in-depth case studies one-by-one. In order to assure the above-detailed coverage of content and extent, we categorised the practices along the following dimensions: timing, place (city), formality, context (formal environment, non-formal learning space etc.), content (coding/making; individual/group activity), number of facilitators required, reach out (number and age-group of participants expected), and planned methods including the types of tools and software to be used.

The activities that feed the case studies are planned to be executed in the first round between March and September 2019 and will be held in one of the major cities within the partner countries (Vienna, Oulu, Berchtesgaden, Heraklion, Msida, Eindhoven, Trondheim, Barcelona, Uppsala and London). Eight from the ten case studies will cover some sort of non-formal science learning activities, while two of the case study activities have the possibility to investigate not only non-formal but informal learning as well. As for the location, in accordance with the formality, most of the activities (6) is planned to take place in varying formal educational environments (classroom, formal educational building etc.), one at a research centre, one at a laboratory, one at a conference site, one at an event hall and one in a pop-up site.

Regarding the content in relation with the focus of the COMnPLAY SCIENCE project, one case study is planned to investigate an activity that includes coding, one includes making, six includes both coding and making, another one includes making and play and one includes playing digital learning games. Regarding the setup within the planned activity, partners report a wide variety: During some of the planned case studies children will work both individually or in small groups (5), while in five case studies participants are planned to work in dyads or triads. The activities are planned to be led by one to three facilitators.

As of the estimated number of participants during the planned case studies the type of the activity has a predetermining role. In most of the cases (9) it means a maximum number of 20 to 40 participants during a given workshop or activity, but in one case the number of participants during the studied faire could reach five to nine-thousand people. Additionally, the planned number of activity occurrences vary from one to four. Hence, it is estimated to reach a total of approximately 500 participants across the workshops and a couple of thousands during the faire.

Regarding the target age group of the planned case studies, a wide range of variety is expected here as well. Most of the activities (7) will cover the 10-16 age group, however, with a varying upper and under limit. This means that the planned activities will reach children from age 7 to 19, therefore children from the primary, secondary and higher education as well.

Regarding the methods, all partners indicated their intention to use the COMnPLAYer app specially developed for the project by Ovos Media. Besides the app, some of the activities (3) are planning to use various paper-pencil-type tools (paper, pencil, post-it, marker, scissors etc.) while others are planned to use for example Scratch, Micro:bit, Lego Mindstorm, Arduino and some are still to be determined. As for the research methods, both quantitative and qualitative tools are planned to be used, for example observations, pre-/post surveys, interviews, screen captures, knowledge tests, multimodal data etc.

We do believe that with the carefully planned selection process we made sure to include a variety of diverse coding, making, and play practices, including children from the age range of 7-19, covering ten European countries.

# 3. The selected practices

In the following pages, we introduce the selected activities for the case studies by country. In each case, the description of the activity involves the reasoning for considering it worthy for in-depth studying.

| **Consortium partner:** | OVOS (Austria) |
| --- | --- |
| | |
| **Name of the selected activity/practice:** | Youth Hackathon |
| | |
| **Description of the practice and reasoning for selection** | |

The Youth Hackathon, a game design competition for students, has been selected as an example of best practice in informal science learning in Austria. The Hackathon (YH) is an event/activity that invites students/classes from different schools to create game prototypes to hand in to the YH competition. The best results are awarded with a prize for the class/the student developers.

Students and classes taking part in the competition are offered workshops for game design basics and programming/using a coding platform like Scratch to create their game prototypes. Additionally, the classes taking part are invited to go on field trips to visit technology focused companies and vocational institutions to find out more about the jobs of the future.

Even though the project works with students and the workshops take place in the classroom, we consider the YH project an example of best practice for informal science learning. As it is clearly defined and separate from regular classroom activities we consider it an appropriate use case and an opportunity for (sparking) informal science learning. There has been research conducted alongside the first round of the competition in 2018 and the event is going to be a recurring one, planned to happen every year.

The number of participants is clearly documented as well as their projects and the size of the target group for qualitative research within the COMnPLAY project seems sizeable enough as well clearly defined. As students create game prototypes, the activity involves coding, design thinking and play testing. So, in our opinion, it perfectly fits the requirements for the research. A game design competition is not directly intended as science learning activity, but the field trips feed an interest in science learning or show possibilities for the students' career paths. It takes place in schools as well as on field trips and it offers learning material to go alongside the project for teachers to deepen the learning around the project. It does not take place independently in everyday life, but it may show the possibilities around game design and might lead students to pursue this activity beyond the scope of the project and take part in game jams or something similar in connection with game design outside of schools.

| | |
|---|---|
| **Consortium partner:** | UOULU (Finland) |
| | |
| **Name of the selected activity/practice:** | Integrating creative design, innovation and criticality into programming education |
| | |

| **Description of the practice and reasoning for selection** |
|---|
| In Finland, programming has been integrated into basic education starting from grade 1 since 2016. There has been an extensive interest in programming education in Finland ever since. In Oulu area, actors such as Buutti, Koodikoulu and Tiedekoulu offer programming and robotics education for children and young people. We see this as a significant development, whereas we also feel that this education lacks emphasis on creative design, innovation and critical thinking. Then again, we have offered such type of education for local comprehensive schools (both primary and high schools) for ten years already and gained positive experiences. Now this type of education needs to be extended to non-formal education context of the young generation. This will entail first conducting research on the existing technology education practices in non-formal context together with the local actors – to map and understand their best practices developed during the past years and that can be considered mature already, and afterwards intertwining ideas and practices from our design, innovation and criticality-oriented projects into their existing practices. Our 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 in small groups. The premises of schools or the Fab Lab of the University of Oulu have been utilized. Fab Lab will be relied on also in the future projects as well as the premises of the local actors already in use. Different kinds of playful methods (for ideation, design, evaluation) and tools (e.g. Robots, LEGOs) will be in use. The projects have developed different kinds of games and they have included game playing by children. Games naturally interest children and they will be utilized as extensively as possible in the future projects as well. |

| **Consortium partner:** | TUM (Germany) |
|---|---|
| | |
| **Name of the selected activity/practice:** | Lego Robotics |

**Description of the practice and reasoning for selection**

The Student Research Centre of the Technical University of Munich, situated in Berchtesgaden designed and established robotics workshop for different levels (beginners or advanced). The time format of the courses is variable: one afternoon, three consecutive days or continuous biweekly meetings over one school year. The workshops are designed in different forms for children and teenagers from the 3rd class (primary school) up to the age of 17 years. On average one third of the children in these courses are girls. At the beginning, the students find out how the robots can interact independently with their environment. Using different sensors, they solve various problems by programming their robot through visual coding. The main intention is to get the students involved in their own projects and to raise interest in STEM subjects (mainly Technology and Engineering). The children work collaboratively in groups of 2-3 participants using a problem-based approach.

Since the robotics workshops and our research take place at the Student Research Center of the Technical University of Munich, we have permanent access to all course contents and all collected data. The facility, which is an extracurricular learning location, offers a sheltered frame for the children and our researches. Within this framework, we enjoy many possibilities of data collection (from questionnaires and individual interviews through to video analyses).

The robotics workshops are also very suitable for intensive, learner-centred research, as the courses, which cover several days, take place regularly throughout the year. This allows, if necessary, measurements to be carried out at several points in time to observe changes in attitudes or behaviour/reactions of the children. In addition, the content of the course itself can be changed and adapted over time.

The robotics workshops take place usually in the afternoon or during the holidays, reflecting the voluntary nature of participation.

Further reasons for our decision for the robotics workshops are the small group sizes (approx. 10 children), working in teams of 2, a certain proportion of female participants and the wide age distribution.

Since the environment of the robots as well as the robots themselves are individually adapted and creatively changed within the workshops, students learn computer science structures and programming techniques in a playful and funny way. In our opinion, these workshops allow to examine all project-relevant aspects (coding, making, play) at once.

| **Consortium partner:** | TUM (Germany) |
|---|---|
| | |
| **Name of the selected activity/practice:** | Programming MOOC |
| | |
| **Description of the practice and reasoning for selection** | |

The TUMDDI group at Technical University of Munich (TUM) regularly offers a MOOC called LOOP as an introductory online course on the basic concepts of object-oriented programming. Currently the MOOC is available in German language only. The target group consists of prospective freshmen of the TUM. Currently, the MOOC is redesigned, aiming to fit a new target group that comprises school students aged 13-18 years.

The primary goal is to teach young people how to program in a playful way, hereby detecting and developing their personal talents and interests in programming and science in general.

The course is based on Constructivism and Constructionism as paradigms for teaching and learning, thus the main activity of the learners is active problem solving in the sense of making. Using various true-to-life examples, the students learn to write their own programs and to solve typical programming problems.

Participants are encouraged to form groups by social networks to share information and to work on projects collaboratively. Of course, the participants can attend lessons and work on projects at any time and from any location.

Participants' activities are tracked to allow researchers to collect data such as solutions of assignments, the learning progress of the participants, the entry and exit events, or the time spent by participants working on the entire course or on individual topics.

In particular, all responses to the assignments, and all programs written by the participants are collected and analyzed. Questionnaires and interviews presumably will help even more to give a clear picture of interesting aspects of this MOOC. This rich dataset allows us to develop the course further over time and adapt it to the needs of learners.

| **Consortium partner:** | FORTH (Greece) |
|---|---|
| | |
| **Name of the selected activity/practice:** | Thinkpetizers: Small bites of Creative Thinking |

**Description of the practice and reasoning for selection**

A fast-paced participative workshop comprising a series of activities (the Thinkpetizers) coaching many different aspects of creative thinking.

The practice is available for study (created & run by a consortium member).

Although the practice is not related to a formal scientific topic or learning goal, the activity promotes and establishes some key elements of creative and scientific thinking, such as the importance and value of ignorance, (self)questioning and not taking things for granted, the value of mistakes and failure, and persistence to one's goals (i.e., not giving up).

The key reasons for which it has been selected include:

(a) In the past 4 years, various versions of it have been successfully applied in about 50 workshops with a total of more than 3000 participants, in 3 different countries (in 2 different languages), in venues ranging from small classrooms to auditoriums and audiences from 10 to 300 people, including students of all ages, parents, educators and the general public.
(b) It is very versatile. It can take place as a student-only activity (with students of any age), as a teacher vocational training activity (towards creating more creative & fun learning activities), as a parent-child shared activity, as well as an open audience activity. It can last from 1 to 5 hours and can be implemented in a large variety of venues.
(c) It embraces fun as a fundamental pedagogical principle.
(d) It includes making and playing.
(e) It is very different from any other practice (even in the field of creative thinking), so it can complement any other studied approach.

| **Consortium partner:** | UOM (Malta) |
| --- | --- |
| | |
| **Name of the selected activity/practice:** | Playing Digital Games for Learning |

**Description of the practice and reasoning for selection**

In the framework of this case study, we are going to examine the cognitive, affective, and social processes and practices playing a game entails. Apart from entertainment, digital games have been established as media that can potentially be powerful tools for learning and teaching. With the appropriate design and implementation they can support learning in affective, social, and cognitive domains. Beyond their potential as tools for teaching content-specific knowledge and skills, research has also situated them in the context of learner-centred educational approaches, learner self-reflection, inquiry-based learning, social awareness, and digital literacy. Nevertheless, they are currently mostly used in informal or non-formal practices and activities, such as after school activities, clubs, or as a leisure activity.

The Institute of Digital Games (IDG) of the University of Malta has an extensive experience in designing, developing, and researching games for learning domain-specific content and developing communication and collaboration skills. It has also organised a number of training events, workshops and playtesting events involving children, young people, educators, practitioners and stakeholders. For such events and activities participants are invited to play with specific digital games.

This case study will involve children and young people aged 11-19 y/o. The participants will be invited to play with specific digital games relevant to the themes and concepts of the project such as scientific literacy, critical thinking, and attitudes to science, in an organised context (e.g. Science Fairs, facilities of the IDG). Although the games employed do embed learning content or the acquisition of knowledge and skills, the activity is not originally intended as a science learning activity.

Playing digital games, depending on their content and context, has been linked certainly to playfulness, fun, and engagement but also to problem-based learning, problem-solving skills, critical thinking, exploration, experimentation, creative thinking, awareness on social, environmental, or humanitarian issues, and communication and collaboration practices. During the study of this practice data regarding the participants' engagement and interaction with the games, and also the learning processes, practices and outcomes that emerge, will be collected through observation, computational tools, questionnaires and interviews or focus groups. This study will provide an excellent opportunity to also focus on and examine the experience and perceptions of the players as learners while playing a digital game in non-formal education settings.

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| **Consortium partner:** | TUE (Netherlands) |
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| **Name of the selected activity/practice:** | SkillsDojo |

**Description of the practice and reasoning for selection**

The SkillsDojo (www.skillsdojo.nl) is a continuously expanding collection of interactive video missions targeting children between age 7 and 12 to introduce 21st century skills (inclusive coding and making) in an interesting, engaging and playful way to children. Since the interactive videos are freely available on the World Wide Web, children can follow them equally well from home alone (younger children with some help) or in a group situation in the class/afterschool care/summer camps etc. The videos are also well-suited to the formal learning environment let them be integrated in the curriculum, offered as a reward activity or introduced by a guest person. The interactive videos build on experimental- and hands-on learning where are no declared learning goals, but topics (missions) from which children can freely choose.

We find SkillsDojo especially suitable for the in-depth studies. We see SkillsDojo as a possible and excellent way to bring informal and non-formal science education techniques and practices into the classroom. The free availability of the videos provides us with a lot of flexibility and it gives opportunity for comparative studies so that besides investigating the content we can eventually test the effect of the environment (e.g. using the videos alone or in a group situation; using them in a formal context or in a non-formal context; using the interactive videos or having the 'video-guy' with the very same activity and setting present in real etc.) We have direct contact with the manager, who is also the maker of the videos and we mutually bear enthusiasm about each other's project which is a very promising and fertile soil for cooperation.

| **Consortium partner:** | NTNU (Norway) |
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| **Name of the selected activity/practice:** | Kodeløypa |
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| **Description of the practice and reasoning for selection** | |
| 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. Children 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. Experienced instructors (student assistants from the Computer Science department with previous experience and training) run the workshops being in constant collaboration with researchers in the University. In addition, upon agreement, using its own portable equipment, the workshop can be run in other learning spaces like classrooms, the local library, community labs. The workshop is conducted in a largely informal setting, as an out-of-school activity, and depending on the need can last 1 to 2 days (five to ten hours) in total. The activity, with the appropriate support from the experienced instructors, is suitable for various student groups, ranging from 8–17 years old. Participants of the workshops can be students informed for the activity with dissemination efforts, but also from "Skolelaboratoriet" at NTNU, which is a resource center for teaching science and is responsible to inform schools in Trondheim and the local coding clubs Norway. | |

| **Consortium partner:** | DFC (Spain) |
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| **Name of the selected activity/practice:** | Workshop I CAN |

**Description of the practice and reasoning for selection**

“Workshops I CAN” are training pills for anyone of any age who wants to explore and learn the Design for Change 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. In these workshops, educators learn how to boost their students' motivation in formal, non-formal or informal education. The activity involves making and playing, as well as creative thinking, design thinking, collaborative learning and problem-based learning.

After experiencing the workshop, educators can adapt the DFC methodology to their own field and start a project with their students. Once the educator has established a framework, children start a DFC project following the methodology. In this project, they are the ones that choose the problem, design a solution for it and carry it out. When children do their projects, these are very often related to science learning since STEM educators that experience the workshop adapt the methodology to a science learning context. However, the flexibility of the methodology makes it possible for students and educators to enrich their science-learning projects with contributions from other fields (e.g. art).

This activity is the most appropriate for an in-depth research since it is very flexible and adaptable to any environment or learning context. Moreover, these workshops take place very often and they are developed by DFC Spain’s own practitioners, so we have immediate access to all information for research purposes.

Workshops can be given in any space and for any organization which is interested in DFC, including formal schools as well as non-formal education organizations. Workshops 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.

| **Consortium partner:** | UU (Sweden) |
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| **Name of the selected activity/practice:** | SciFest |
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| **Description of the practice and reasoning for selection** | |
| SciFest is a three-day science fair targeting school classes (formal education) and the general public. The fair is arranged and coordinated by UU. The activities are carried out by university staff or related stakeholders.<br>The activity offers good opportunities for studying participation (outreach), especially since the marketing through the schools reach a wide audience. The dual target audiences allow for studying potential differences in science capital between those that visit as part of school classes and those that are informal visitors and make the effort to attend an activity that is highly outside the everyday life. Questionnaires and the COMnPLAY app will be used to collect data related to performing such a study.<br>The main purpose of the SciFest activity is to inspire interest in science and science education, rather than specific learning objectives. There are however several activities in the fair that offer learning type activities of mainly making and playing kinds. These activities can be observed. We see the SciFest activity as an excellent opportunity to gather a broad span of interesting data that is relevant in connection to differences in science capital background. | |

| Consortium partner: | KCL (United Kingdom) |
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| Name of the selected activity/practice: | Youth Maker Spaces |

**Description of the practice and reasoning for selection**

We will be examining the practices in two maker space programmes in order to compare and contrast features and thus gain a stronger sense of what constitutes effective practice with respect to the facilitation and organisation of making activities targeted at young people.

The first setting is located in west London in an area undergoing urban renewal. The maker space facility is run by the local University. In providing the facility the University is keen to contribute to its locale, but also facilitate local youth's potential engagement in Higher Education at the University, or at other institutions.

The activities provided comprise workshops lasting a set time, and with an overt, albeit broad, educational objective (in the areas of science, and design and technology). In addition, the facility is open for local youth to participate on a more casual basis and to engage in making projects of their own volition (encompassing all topic areas and interests). Both are supported by dedicated staff and a variety of tools and materials are available to use.

The second setting is a pop-up venture run by an educational charity. The maker-space activities vary with available locations. Some sessions are run for school groups, others are for general public (youth and adults) and run across weekend days. As above, both are supported by dedicated staff. The focus is not necessarily 'science', but more supporting young people to develop skills of making, enquiry, questioning and creative thinking.

Both ventures have been recommended by colleagues and practitioners working in the area of making/coding/play as sites of innovation. Significantly, both ventures admit that they have plenty to learn with respect to facilitating youth engagement and developing programmes and resources that best fulfil the needs of their audiences. It is because they are keen to learn and improve that I regard these ventures as examples of best practice in making/coding/play.