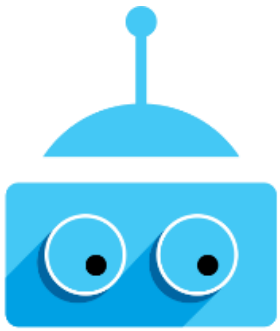

COM n PLAY
SCIENCE

## PROJECT DELIVERABLE

# D4.3. PROCEEDINGS OF THE FIRST COM N PLAY SCIENCE RESEARCH AND INNOVATION WORKSHOP

Dissemination level: public

v.2.0 (Final)
28 October 2019

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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

**Type of Action**

Research and Innovation action

**Grant Agreement**

No 787476

**Duration**

36 months (1/6/2018 – 31/5/2021)

**Grant Amount**

€ 3,097,715.00

**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 analyze 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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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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# Introduction

This report consists of the proceedings of the FabLearn Europe 2019 conference, under which the First COM n PLAY Science Research and Innovation Workshop was organized in May 2019 at the University of Oulu, Finland, with a strong focus on informal science learning through making, coding, and play activities. The conference involved selected practitioners and concluded the project and acted as the starting point for the deployment of a continuing campaign for the exploitation of the project outcomes after the end of the funded period.

The initial project research results on the identified and pooled practices (Task 2.1 Identification and pooling of practices; Task 2.2 Selection of practices; D2.1 Identified Practices and Research Sample) were presented by the paper entitled *The role of age and gender on implementing informal and non-formal science learning activities for children* (page 12).

During the three days of the conference eighteen research papers, five workshops and two demos were presented. The conference was visited by approximately 80 professionals from all across Europe.

This deliverable is available in electronic form through the project website.

# FabLearn Europe

## 2019

## 28-29 May 2019, University of Oulu, Finland

# Summary of works presented


This conference is organized in collaboration with the COMnPLAY project, which has received funding from the European Commission's Horizon 2020 SwafS-11-2017 Program (Project Number: 787476). The contents of this website do not represent the views of the European Commission and the Commission cannot be held responsible for any use which may be made of the information contained therein.

# Summary of works presented

## Paper Session I: Meanings-making around FabLearn

### Widening the scope of FabLearn Research: Integrating Computational Thinking, Design and Making

*Eva Eriksson, Ole Sejer Iversen, Gökçe Elif Baykal, Maarten Van Mechelen, Rachel Smith, Marie-Louise Wagner, Bjarke Vognstrup Fog, Clemens Klokmose, Bronwyn Cumbo, Arthur Hjorth, Line Have Musaeus, Marianne Graves Petersen, Niels Olof Bouvin.*
Full Paper

FabLearn has primarily been concerned with studies of digital fabrication technologies in education, however, we witness an increased interest in integrating other related topics such as computational thinking, digital design and empowerment as an integrated whole. In this paper, we present a five years design research program for digital fabrication, computational thinking and design, to highlight why the FabLearn community should embrace this wider agenda to accomplish its ultimate goal to encourage a new generation to critically and constructively engage in the design of digital technology. The contribution of this paper is a number of open questions and considerations regarding the scope of European FabLearn research that we hope the community will consider and that might give rise to further discussions

### Empowered to Make a Change - Guidelines for Empowering the Young Generation in and through Digital Technology Design

*Marianne Kinnula and Netta Iivari*
Full Paper

This paper scrutinizes how children can be empowered to make a change through acquiring skills in digital technology design. We propose a framework that integrates theoretical understanding from literature on nexus analysis, values, and value as well as empowerment and genuine participation of children, and a related tool for educators and researchers advocating empowerment and inclusion. They should benefit from this tool when planning, analyzing, and evaluating their projects. We argue that the tool is useful beyond studies with children and can be used as a practical tool when planning and implementing digital technology design projects with any group of people and as a theoretical tool when studying such endeavors, especially when working with vulnerable or underserved participants.

### "The STEAM path": building a Community of Practice for local schools around STEAM and Digital Fabrication

*Iván Sánchez Milara, Kati Pitkänen, Arto Niva, Megumi Iwata, Jari Laru and Jukka Riekki*
Poster Paper

With this poster, we present our goals, methodology and initial findings of the first 7 months of a pilot aiming to integrate STEAM education in formal education by exploiting digital fabrication tools and processes. The success of the pilot is strongly bound to the development of a Community of Practice formed by diverse local stakeholders including teachers, school principals, education administration representatives, researchers and Fab Lab instructors. Six local schools participated

in the first stage of the pilot. We claim that this poster will set the ground for a discussion on how to integrate STEAM and digital fabrication procedures in formal learning environments. We expect our experience could serve as an inspiration for similar projects all around Europe.

### Meanings in Digital Fabrication

*Georgi V. Georgiev*
Poster Paper

The aim of this study is to investigate the drivers of physical realization of meaningful objects, in particular, how these drivers can contribute to prototyping of products. An intensive digital fabrication workshop, a part of a summer school, is used as a case study. We discuss the results of the workshop in terms of the background of the participants and their motivation in the perspective of the rationale of their prototypes. We identify how the background and motivation of teams of the participants influenced the meaning making in digitally fabricated prototypes.

## Paper Session II: FabLearn and higher education

### Academic Recognition of Fab Academy

*Jani Ylioja, Georgi Georgiev, Ivan Sanchez and Jukka Riekki*
Full Paper

Maker educations and distributed educations are increasing in quantity and quality. This gives a possibility for academia to tap into interesting sources of knowledge outside the physical parameters of the institution, as well as outside formal education and traditional learning methods. However, academic recognition of such learning can be challenging. We explore Fab Academy in comparison with a current university course with the same topic; the amount of work by university standards and whether the assessment methods of Fab Academy are sufficient for academic recognition. The workload of Fab Academy is calculated based on the European Credit Transfer and Accumulation System (ECTS). The contents are compared based on the range of subjects and the deliverables required to pass the courses. We find Fab Academy to be compatible with the university course. Hence, we consider it possible to include in university curriculum Fab Academy content accredited by different universities.

### Evaluating a Makerspace Visiting Program for Schools at a University of Teacher Education

*Dorit Assaf, Josef Buchner and Andreas Jud.*
Poster Paper

In this paper, we describe a preliminary study that has been conducted to evaluate a makerspace visiting program for regional schools of compulsory education at the University of Teacher Education St. Gallen in Switzerland. We describe the program setup as well as the challenges since its launch in 2015. A survey among the teachers that visited the program with their students collected data about the teachers' personal information, their experiences during the visit, the impact on their teaching as well as their wishes for a further development of the program. Findings include that the makerspace activities were regarded as highly curriculum-relevant. Many teachers introduced similar activities in their own classrooms. The study shows, that the highly instructional

activities, which are unlike a typical makerspace environment, were a successful approach to increase acceptance of both faculty members and teachers. Lastly, we discuss how the program could be further developed.

### The Potential of Making for Enhancement of Digital Competencies in Higher Education

*Bonny Brandenburger and Gergana Vladova*
Poster Paper

An increasing interaction between man and machine in all areas of society leads to not only new job profiles but also initiates a discussion about the needed digital competencies in the future. The European Commission's Joint Research Centre has developed an initial framework to describe the needed competencies such as problem solving ability, capacity of teamwork and programming skills [5]. It is expected that the transfer of technical, occupation-oriented and personality-building competencies alongside subject-related knowledge will become increasingly important in higher education [1]. In order to avoid inequalities among students -those with and without so-called digital competencies - new teaching methods are needed. In this regard, the following poster creates a new link between the DigComp 2.1 framework for citizens and making in higher education based on a literature review.

### Digital Fabrication and Collaborative Projects in Promoting Student Engagement and Motivation

*Teemu Tokola, Niklas Saari, Juha Kälkäinen and Juha Röning.*
Poster Paper

Project work represents a significant part of university studies, making them an important concern for teaching development. Many universities have used international engineering competitions such as the Eurobot robotics competition as a tool in engaging and motivating students. Based on a theory on why these competitions are successful, we propose how smaller-scale projects can use digital fabrication and joint projects to reach similar results. We present a case study of an ongoing robotics project course in the field of computer engineering, showing how a practical implementation of these ideas and how the field-specific problem of software intercommunication and interoperability can be solved using the Robotic Operating System software framework. While the course is still in progress, initial observations indicate that the course is going to be successful.

### Designing a Hands-on Learning Space for the New Generation

*Lorenzo Angeli, Francesca Fiore, Alberto Montresor and Maurizio Marchese*
Poster Paper

In this poster paper, we present a “design document” for a fab lab in development at the University of Trento, in Italy. We discuss why and how some elements of the fab lab can be rethought for the current generation of Higher Education students, which, we argue, has different features than the one originally targeted by these structures. We discuss the three main design elements that we use: matching high- and low-tech fabrication; constructivist education; and interdisciplinarity. Finally, we outline relevant stakeholders for this type of initiative and how they can be empowered and integrated in the lab’s architecture.

# Paper Session III: Learning and Collaboration

## Supporting Fab Lab facilitators to develop pedagogical practices to improve learning in digital fabrication activities

*Kati Pitkänen, Megumi Iwata and Jari Laru*
Full Paper

Planning and facilitating digital fabrication activities, where students engage in creating tangible artefacts with digital technology, requires knowledge on both technology and pedagogy. Currently, most of the studies see facilitators of digital fabrication activities as technology experts and there are only few studies regarding them as educators. There is not much discussion from the learning sciences point of view, considering what are the requirements to enhance learning in the activities. To fill these research gaps, this paper aims to provide theoretically grounded practical suggestions of how the facilitators may contribute to improve students' learning in digital fabrication activities based on learning science propostions. The aim of this study was to explore, how Fab Lab facilitators and school teachers can design digital fabrication activities to support students' learning. We explored the current practices in Fab Lab Oulu from the two perspectives: considering novice students' learning and scaffolding ill-structured problem-solving. We suggest that the facilitators may improve students' learning by taking into account their background and current learning processes, applying instructional scaffolding, and supporting teachers involvement to take active role in the activities.

## Scaffolding of Learning in Library Makerspaces

*Árni Már Einarsson and Morten Hertzum*
Full Paper

Makerspaces have spread to libraries in recent years, to promote equitable access to technologies, expand services, and encourage participation and learning. In this paper, scaffolding of learning is studied from the perspective of library makerspace practitioners. On the basis of interviews in six Danish libraries, we analyze formal, non-formal, and informal activities and identify seven ways of scaffolding. Three challenges are discussed: (a) fostering community while ensuring inclusion in informal activities, (b) avoiding to stifle creativity in short-term activities, and (c) finding the role of the library in formal activities. We propose actions to overcome these challenges, such as encouraging scaffolds across formal, non-formal and informal learning activities and addressing the educational role of the library.

## Material objects as tools for organizing collaboration in maker-centered learning

*Varpu Yrjönsuuri, Kaiju Kangas and Pirita Seitamaa-Hakkarainen*
Poster Paper

Materialization of ideas is an essential aspect of maker-centered learning. The role of materiality, however, is little researched area, especially among young students. Our aim in the present study is to explore how material objects are involved in organization of collaboration in a secondary school co-invention project, where students collaboratively created smart products or garments. The data consists of video-recordings of ten design sessions of one student-team. We conducted the analysis on three different levels: macro, intermediate, and micro, to create a systematic and focused

analysis of rich video data. The preliminary results indicate that various material objects are in many ways involved in students' interaction. Objects appeared during activity shifts and in distribution of turns at talk. To support interaction, students coordinated attention towards objects with gestures and words. A more detailed analysis is currently ongoing.

### Supporting creativity and collaboration: Considerations for the development of a technologically enhanced toolkit for kindergartens

*Nadine Dittert, Sarah Robinson, Klaus Thestrup and Jacob Knudsen*
Poster Paper

Creativity and collaboration are 21st century skills that should be supported throughout schooling. In the SEEDS project we are in the process of developing a technologically enhanced toolkit for kindergartners to support creativity and collaboration in a kindergarten setting. In this paper we will showcase our first ideas, prototypes, and initial findings from developing the toolkit with six children and one teacher. By presenting opportunities to experiment with a range of simple, recognisable everyday materials, both digital and non-digital, that the kindergartens have at hand, we seek to find ways to open up to creativity and support collaborative skills through the medium of story-telling.

## Paper Session IV: Variety in FabLearn: divergent participants, contexts, topics and tools

### The role of the age and gender on implementing informal and non-formal science learning activities for children

*Gabriella Tisza, Sofia Papavlasopoulou, Dimitra Christidou, Iro Voulgari, Netta Iivari, Michail N Giannakos, Marianne Kinnula and Panos Markopoulos*
Full Paper

There is a growing number of informal and non-formal learning activities worldwide related to STEM (Science, Technology, Engineering, Mathematics) subject areas – particularly, those related to coding and making. To understand the general aim and content of such activities, we conducted a survey addressing highly experienced instructional designers and instructors of informal and non-formal science learning activities in nine European countries (N=128). The goal of this paper is to investigate the relation between (1) the targeted age-group and (2) the gender of the participants in these activities, and (3) the gender of the activity leader experts and (I) the content and (II) the main goal of the activity. The results show that the gender and age of the participants and the gender of the activity leader experts are associated with regards to the underlined content and the goal of the activity. We introduce the revealed patterns that describe typical goals and content in association with the participant's gender and age along with patterns between the activity leader experts' gender and the content and the main goal of the activity. We discuss the study findings in detail, their implications and their value for the informal and non-formal learning communities.

## Effects of physical computing workshops on girls' attitudes towards computer science

*Eva-Sophie Katterfeldt, Sobin Ghose, Nadine Dittert, Arne Bernin and Mareike Daeglau*
Poster Paper

Making is frequently utilised to promote disciplines such as computer science to new students. We investigated how Maker workshops on physical computing contribute to shaping girls' attitudes and perceptions towards computer science. We evaluated 25 physical computing workshops exclusively for girls aged 9-18 to explore potential changes of attitude towards computer science with pre and post surveys (n=135). Overall, the evaluation results show small effects for one third of items which may indicate that Maker workshops with physical computing material can support a balanced attitude towards diversity in the presence of and scope of computer science among girls.

## Smart Cities Initiative: Making New Choices for a Sustainable Future

*Rodrigo Lemonica*
Poster Paper

The paper presents the "Smart Cities project" developed with 9th grade students from Lourenço Castanho School, 'Lourenço' is a private school located in São Paulo, Brazil, which has a creative space known as 'Creation Lab.'; this ecosystem at school intends to develop a culture of innovation and creativity. Through the problem: 'Can tech improve quality of life in a city?' and working in a 'STEM-Maker' scenario, students built their own town, using waste, scrap, Arduino and the IoT (Internet of Things), they made smart prototypes to the city aiming an efficient and innovative solution for many global issues. Linking maker movement and citizenship through the project in group action, it was emphasized the fundamental role of citizenship in a whole school community, understanding that 'citizenship is everyone's duty'.

## Safety Culture in Digital Fabrication: Professional, Social, and Environmental Responsibilities

*Dorina Rajanen and Mikko Rajanen*
Poster Paper

This paper addresses the safety culture as a concept in the context of digital fabrication. The aim of the paper is to provide a basis for the understanding and adoption of safety culture in digital fabrication, makerspaces and fab labs. The paper outlines the concept of safety culture in digital fabrication through three dimensions of safety culture: professional, social, and environmental responsibilities. We propose that these dimensions can act as motivators in adopting a correct safety behavior in the context of digital fabrication education.

## How are Mobile Makerspaces Utilized in Schools?

*Megumi Iwata, Kati Pitkänen, Jani Ylioja, Iván Sánchez Milara and Jari Laru*
Poster paper

To explore diverse means to apply digital fabrication in formal education, this poster presents an overview of the literature regarding the use of mobile makerspaces in K-12 school contexts. Among the reviewed literature, mobile makerspace activities were integrated with school curriculums, especially in STEM fields, and teachers were highly involved in planning and implementing the activities. We noticed that technology experts support the activities as well as teachers' professional

development by providing technical assistance. Our findings contribute to uncover the current practices of mobile makerspaces and call for in-depth scientific investigation.

## Workshops

### Fab:UNIverse – Makerspaces, Fab Labs and Lab Managers in Academia

*Oliver Stickel, Melanie Stilz, Anke Brocker, Jan Borchers and Volkmar Pipek*
Workshop Paper

Fab Labs and ”Maker” practices have been recognized in research and practice as contexts that facilitate creativity, knowledge sharing and collaboration ([4], [10]). Personal digital fabrication is getting increasing attention from various fields like education, engineering, innovation, design, humanitarian aid or regional development ([6], [1], [7], [3]). However, integrating Fab Lab environments into academic education is still challenging in practice. In Germany, more than 200 such creative community spaces exist [5]; around 15 of these are associated with universities. Most are initiated and run by single entities such as student groups or university chairs and are not integrated in the universities’ overall organizational matters. The federal research project ’FAB101’ aims to consolidate organizational and educational knowledge based on experiences in four Fab Labs at German universities [9]. We propose a workshop to share and discuss results, to open up our ongoing research to a European community and to encourage collaboration between academic Lab coordinators.

### Co-creation of a Safety Culture in Digital Fabrication

*Dorina Rajanen and Mikko Rajanen*
Workshop Paper

This workshop is intended to anyone (students, teachers, practitioners, technologists, designers, academics, etc.) working within or interested in the digital fabrication field. The workshop focuses on promoting, adopting, and developing a safety culture in digital fabrication. During the workshop, the participants will share information and experiences about safety in digital fabrication. A co-creation activity is organized where participants engage in the ideation, design, and prototyping of a storyboard for promoting safety in digital fabrication.

### Meso-Level Strategies for Design Participation and Education: Libraries as networked learning spaces

*Aale Luusua, Johanna Ylipulli and Matti Pouke*
Workshop Paper

Design participation and education are important vehicles for building citizenship skills in democratic societies. However, there is a considerable gap between macro-level aims to include the civil society at large and Participatory Design (PD) methods to include citizens on the micro-level. Thus, we argue for meso-level approaches that would enable PD and education practitioners to build scalable methods of digital inclusion. We present the case of Virtual Library in Oulu City Library as a hands-on case study example in our workshop. In order to build scalable methods, we offer libraries as an example of a networked learning space to achieve this synergistically with an existing social and cultural service program, the public library system. We invite practitioners, educators and

scholars from all backgrounds to explore, develop and critique meso-level approaches and networked learning spaces in their various cultural and national contexts of practice at this two-hour long workshop.

### Polargraph The Project

*Dimitra Tsoumpri*
Workshop Paper

The 21st Century has been characterized by the dawn of the 3rd Industrial Revolution regarding the way we share knowledge and build things. Open Source and Digital Fabrication has affected the way we learn and build things but not the way we teach things. The classic educational model of the teacher opposed to the student is in contradiction to the spirit of the Shared Knowledge students are familiar with, through the internet. DIY projects bridge the gap between the tutor and the student by using the process of a Do It Yourself project and the guidance of the tutor. Our lab conducts a DIY workshop as a - hands on, multidisciplinary, education - process. The project is about putting together a vertical plotter, Polargraph, and programming it via Arduino and Processing. The students work in teams regarding the different scientific areas of the project. The process is based on a -hands on- approach where the students do their research; they put their idea to the test and try to find the error through tests and observation. The workshop meant for the conference is a short version of the original program, meant to introduce the attendees to a DIY educational process.

### Thinkpetizers: Small mental bites of Creative Thinking

*Dimitris Grammenos*
Workshop Paper

A fast-paced hands-on workshop introducing the concept and practice of Thinkpetizers. The workshop presents the underlying philosophy and a ‘recipe’ for successfully creating Thinkpetizers, along with how they used as building blocks for creating multi-hour workshops, sessions and events. The Thinkpetizers support the step that precedes (digital and analogue) fabrication, i.e., coming up with creative and innovative ideas. They can also be used for refreshing one’s mind and creative powers throughout the whole creation process. Furthermore, they can be used in a classroom setting as a means for triggering (creative) thinking and setting the mood for conducting any type of activity, but also as an engaging way for approaching any learning subject. The workshop is targeted to anyone interested in supporting creative thinking in a formal/non-formal/ informal learning environment. Participants will experience a design philosophy, as well as, a series of practical activities and will have a lot of FUN!.

## Demos

### Fostering creativity in computer science classes by telling stories

*Thomas Schmalfeldt*
Demo Paper

Creative thinking and mastery of computer science skills are two important competencies in the 21st century. This article outlines an approach to help students foster their creativity while learning

programming concepts. The Story Cards make use of the Calliope mini, a microcontroller which allows for a physical computing approach. When a student has learned a new programming concept, he or she receives the corresponding Story Card. The goal of the cards is for students not only to build things but also to tell stories using their acquired programming skills.

### Paper Pocket Pets – Making Wearable Interactive Toys

*Susanne Stigberg, Eleonora Mencarini, Andreas Heiberg and Daniel Bhadurkhan*
Demo Paper

We present Paper Pocket Pets, an approach to create personal interactive toys that children can carry along with them. Creating Paper Pocket Pets involves four activities that combine traditional crafts with digital fabrication: paper folding to create a pet; fabrication of the pet's shelter (a platform where the pet lives on); fabrication of the pet's electric components; and programming the pet's behavior. We invite the FabLearn audience to create their own pets and explore these activities during the demo at the conference.