# STEAM Learning in formal and informal settings via craft and maker projects

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## Abstract

Teams of students creating digital artefacts using crafts, 3D printing, electronics, microcontrollers, and computer programming can result in significant science, technology, engineering, art, and mathematics (STEAM) learning. An ecosystem of carefully selected tools, diverse project ideas, and a well-designed pedagogic structure can greatly facilitate this.

The workshop will begin with a presentation by the eCraft2Learn project funded by the European Union's Horizon 2020 Framework. This includes a unified user interface to a large set of tools for ideation, planning, creating, programming, and sharing. Support has been developed to enable children to create AI programs that rely upon cloud services [1]. Learning analytics provides guidance to teachers and coaches [2] [3]. An augmented reality application has been developed to aid team 3D design. Results from pilot studies will be presented.

Following the eCraft2Learn presentations researchers from the world over that are working on incorporating the maker movement into education and learning will

present and demonstrate their work. Participants will determine topics for panel discussions.


## Author Keywords

STEAM; STEM; Physical computing; Maker Movement; Raspberry Pi; Arduino; Crafts; 3D design; 3D printing; Visual programming

## ACM Classification Keywords

K.3.1 Computer Uses in Education; K.3.2 Computer and Information Science Education; H.5.2 User-centered design; I.2.9 Robotics; I.2.5 Programming Languages and Software


## Introduction

Many conference attendees are focussed on pieces of the workshop topic. The workshop will provide the opportunity to see the bigger picture and discuss with others working on other pieces. Some of the pieces are pedagogic, involving different ways of introducing maker culture and technologies for education to support student projects. This involves not only the "making" stage but also the idea formation, the planning, the programming of the behaviour of the student creations, and sharing. Other pieces are technological consisting of topics around electronics, Arduinos, Raspberry Pis, 3D design, 3D printing, block-based programming language, AI cloud services, augmented reality, and learning analytics. Other pieces of the big picture involve the connection with science and mathematics. And finally there is also craft, design, and art. During the workshop we will put all of these pieces together. The eCraft2Learn project works on creating a relevant pedagogical model for personalised learning and teaching within science, technology, engineering, arts and math (STEAM) education. The aim is to close the skills gap between the skills learned at schools and the skills needed in the ICT, design, and engineering sectors, which hinders economic growth. Digital technology assets can be used to help create an education and innovation ecosystem to overcome these problems.

Digital technology has radically changed the way people work in industry, finance, services, media and commerce [4] and has urged necessary corresponding changes in educational systems. However, there is a lack of progress in the education arena [5]. Hence, recent studies show that high percentages of college graduates can't find work, the dropout rate is high and new generations are moving back into their parents' homes after school or college (see for example [6]). Nevertheless, the digital trend indicates that today's grade-school children will end up at jobs that have not been invented yet. Nowadays, several studies assure that digital fabrication and making technologies, if coupled with proper learning methodologies such as Constructivism and Constructionism can provide learning experiences that promote young people's creativity, critical thinking, teamwork, and problem solving skills, which are essential and necessary in the workplace of the 21st century [7]. However, as early as 2008 an OECD report remarked that "technology is everywhere, except in schools". In addition to this, most uses of technologies in education and training today do not support 21st-century learning skills. In many cases, new technologies are simply reinforcing old ways of training and learning in current school settings and very often they are introduced according to a narrow perception as being suitable only for talented youth or only for Science-, Maths- or Engineering-oriented majors [8] [9]. Current

developments call for a move from this elitism to the recognition that fluency with making technologies represents knowledge and skills valuable for every citizen.

The eCraft2Learn project is researching, designing, piloting and validating an ecosystem based on digital fabrication and making technologies for creating computer-supported artefacts. The project aims at reinforcing personalised learning and teaching in science, technology, engineering, arts and math (STEAM) education and to assist the development of 21st century skills that promote inclusion and employability for youth in the EU. The project is putting forward a learning ecosystem that integrates a craft- and project-based pedagogy with technologies for making in order to bring the maker culture into the educational arena. The eCraft2Learn ecosystem supports both formal and informal learning by providing the appropriate digital fabrication, making technologies, and programming tools through a unified user interface. It is also incorporating mechanisms for personalised and adaptive learning.

**Workshop Structure**

Morning session - Laying down the theoretical path

Introduction to the workshop - interactive activity among participants (9:00 to 9:10 minutes)

eCraft2Learn presentations. Presentations by members of the eCraft2Learn project on topics ranging from technical and pedagogic research around applying craft and Maker Movement ideas and tools to learn science, technology, engineering, art, and mathematics (STEAM), a web-based unified user interface to tools and resources, AI-extensions to Snap! to enable students to build intelligent apps and artefacts, learning analytics, and an augmented reality app designed to aid teams of students doing 3D designs.

Coffee Break - free networking (10:00 to 10:15)

Short presentations and demonstrations from accepted submissions, not associated with the eCraft2Learn project (60 minutes)

A panel discussion driven largely by questions from the participants. (60 minutes)

Lunch break (provided by IDC, 12:15 to 13:30)

Afternoon session - Hands on experience

Hands-on experiences with the eCraft2Learn ecosystem - pedagogical integration to technologies for making (group work using Raspberry Pis, Arduinos, electronics, and AI-extensions to the Snap! Visual programming language, through the proposed five stages pedagogical approach).

Participants will experience first-hand the Lighthouse Project which involves using a Raspberry Pi, an Arduino, LEDs, visual programming, and crafts. Two levels of difficulties will be available according to how fast the participants progress with developing the task. (13:30 to 15:15)

Coffee Break - free networking (15:15 to 15:45)

Accepted submissions will have a time slot for enabling the audience to interact with the systems or

technologies that they have been using/developing. Group work will be encouraged. (15:45 to 16:45)

Wrap up, collection of tips and best practices to bring the maker movement to the classroom (we will require a pedagogical focus on the given tips/best practices) (16:45 to 17:15)

If, as we hope, school children visit the workshop during the last hour, the schedule may change a little.The full-day workshop will split the time equally between theoretical aspects of making in educational settings including eCraft2Learn project reports, participant presentations, and the panel discussions (morning session) and hands-on exercises from the eCraft2Learn project as well as selected participants' project works (afternoon session).

## Pre-Workshop Plans

eCraft2Learn project members from 12 organisations spread over 6 European countries will help recruit participants. The project website will be used to advertise the workshop.

## Post-Workshop Plans

We plan to write and publish a workshop report. All presentations will be available on our website. We are exploring the possibility of a special issue of the Springer open-access journal *Research and Practice in Technology Enhanced Learning* based upon workshop contributions.

## Call for Participation

The "STEAM Learning in formal and informal settings via craft and maker projects" workshop will be a great opportunity for anyone interested in how crafts, 3D printing, 3D design, electronics, microcontrollers, robotics, visual programming, and AI can be used in creative ways by learners. In addition to hearing about and seeing demonstrations of the work by twelve partners of the European eCraft2Learn project (https://project.ecraft2learn.eu/) there will be participant presentations and an audience-driven panel discussion. The second half of the workshop will consist of hands-on tasks. The first part of the hands-on tasks will be based upon activities piloted with children. Raspberry Pis, Arduinos, sensors, and craft material will be provided. Please bring your laptop. This will be followed by maker or physical computing activities that selected workshop participants would like to share. The workshop will focus upon pedagogic, cultural, and social issues in addition to the technical challenges of introducing Maker technology into schools and informal settings.

We encourage submissions about research, experiences in the field, and work-in-progress that involves STEAM and the Maker Movement. Papers must be formatted according to ACM Extended Abstract Template and must not exceed 2-4 pages. Authors are encouraged to present their work as videos, demos or hands-on activities. Please specify this option during submission and provide information about the demo. Send your submissions to office@ecraft2learn.eu. At least one author should attend the workshop and main conference.

Possible presentation topics include (but are not limited to this list):

- Maker movement in schools
- Physical computing

- STEAM in the context of formal and informal learning
- AI programming by children
- Learning analytics
- 3D printing and design in education
- Craft-based projects
- Raspberry Pi and Arduino programming

## Organizers

Dr. Ken Kahn is a researcher at the University of Oxford. He has been researching programming environments for children since he was a graduate student at the MIT AI Lab in the 1970s. He is the designer and implementer of several systems including ToonTalk, the Behaviour Composer, and MoPix, He has been actively publishing in the field of visual programming for over 25 years. For three winters he taught a course on computational thinking and modelling at the National University of Singapore. He is the lead on the eCraft2Learn efforts to enable students to build AI apps and artefacts.

Dr. Calkin Suero Montero is a senior researcher at edTech group, School of Computing, University of Eastern Finland. Dr. Suero Montero received her PhD in computer science from Hokkaido University, Japan (2008). Her main research interests are related to Human Language Technologies (HLT) applications such as conversational system; designing and implementing algorithms for text-based Affective Computing; investigating the social acceptance of novel human-computer interactions, such as gesture-based mobile interactions designs; and computer supported collaborative work in educational settings. Calkin is the eCraft2Learn project coordinator.

Dr. Christian Voigt has a degree in Business Informatics and a PhD in Information Systems (2008). He has extensive experience as project manager, researcher and lecturer in a number of countries (Austria, Germany, Australia and Singapore). His main expertise lies in the use of technology to enable digital innovations in education, workplaces and life in general (e-participation). Christian joined the Centre for Social Innovation in 2010, where he is leading the 'Knowledge & Technology' Unit since 2012. Over the past years, he has been actively involved in European research projects related to educational technology, research e-infrastructures and foresight studies. Currently, Christian is working on social innovations promoting e-inclusion (crowdsourcing geo-data) and promoting learning networks in maker communities. In the field of academia, he teaches at the University of Vienna ('Information technology and society' and 'Didactical design') and at the Dabube University Krems ('P2P for Social Innovation').

Dr. Nuno Otero is an Associate Professor at the Computer Science and Media Technology Department of the Faculty of Technology at Linnaeus University (LNU) in Sweden. He is interested on theories and conceptual frameworks in Human-Computer Interaction, from more traditional approaches taking a user centred perspective to more recent trends focusing on user's experiences with technologies. In a nutshell, the question driving his research concerns the understanding of how the properties of distinct devices, computational artefacts and embedded external representations impact on people's activities (from work related activities to educational and ludic contexts).

Dr. Marcelo Milrad is a Full Professor of Media Technology at the Faculty of Technology at Linnaeus University (LNU) in Sweden. He is also the director of the Center for Learning and Knowledge Technologies (CeLeKT). His current research interests include the design of learning environments to support learning about complex domains, collaborative discovery learning and the development of mobile and wireless applications to support collaborative learning. During the last years he has been serving as a program committee member in a number of international scientific conferences such as CSCL, ICALT, WMUTE, ICCE and mLearn. He is also an editorial board member in several scientific journals in the field of Technology Enhanced Learning. He has acted as an executive member of the IEEE Computer Society Technical Committee on Learning Technology (LTTC) and he is one of the initiators of the IEEE International Conference on Wireless and Mobile Technologies in Education (WMTE).

## Workshop Website

It will be pages on https://project.ecraft2learn.eu/

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