eCraft2Learn

Digital Fabrication and Maker Movement in Education
Making Computer – supported Artefacts from Scratch

Deliverable D6.3

Publication Summary

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 731345.

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	University of Padua, Italy, (UNIPD)
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Reviewers:	**Sara Therner** [ARD]

Version Control

Version	Date	Person in charge (Organization)	Changes	Quality Assurance
1	01.11.2018	Baran Çürüklü [MDH]	Initial version with the publication list and abstracts, etc.	Afshin Ameri [MDH]
2	22.11.2018	Calkin Suero Montero [UEF]	Final version.	Baran Çürüklü [MDH]
3	25.11.2018	Sara Therner [ARD]	Review	Afshin Ameri [MDH]
4	27.11.2018	Baran Çürüklü [MDH]	Refinements based on reviews	Afshin Ameri [MDH]

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EXECUTIVE SUMMARY

This deliverable reports the scientific publications, which have been produced as a result of the eCraft2Learn project. The intention has been to publish in a way that would allow rapid dissemination of scientific outcomes. This has been achieved through fostering the research community access to the outcomes in conferences as well as congresses. Furthermore, **open access to publications as per the Commission guidelines** has been followed whenever possible (Article 29.2 model grant agreement[1]).

[1] http://ec.europa.eu/research/openscience/index.cfm?pg=openaccess

1 INTRODUCTION

The purpose of this deliverable to report the output of the project with respect to scientific publications. Publications are an important part of every research and innovation project. As can be seen from the list in Section 2 the publications are multi-faceted, since the eCraft2Learn project is multidisciplinary in its nature. These publications have addressed aspects of the technical core as well as the pedagogical approach of the eCraft2Learn learning ecosystem including the project's general overview [1, 3, 14, 15], as well as the practical implementation of the project from the pedagogical, teacher training and pilots perspective [2, 4, 5, 6, 16]. Publications related to the technical core are represented through the badging system for fostering self-assessment [2], artificial intelligence (AI) programming in Snap! [8, 9, 11, 12], AI in combination with DIY hardware [13] and learning analytics [17]. It is important to note, however, that it is not possible to draw a clear line between different technologies in the context of the publications. One of the ambitions has been to increase the impact of the project through peer-reviewed publications that lead to academic workshops or demonstrations at internationally renowned conferences [7, 8, 10, 14, 15]. The innovation potential of the outcomes of the project has been elaborated through peer-reviewed full paper publications as well [18-20]. These publications complement the other dissemination to contribute to the dissemination of the scientific outcomes of the project.

2 PUBLICATIONS

The project output regarding the publications, including workshops and demonstrations, is summarized in the table below. This list reflects status at M22 in the project. The publications are accessible through the project website (https://project.ecraft2learn.eu/publications/) as well as the project Zenodo repository (https://www.zenodo.org/search?page=1&size=20&q=eCraft2Learn).

Table 1: List of publications

Number	Publication type (Conference, Demonstration, Journal, Technical report)	Publication data
1	Journal	Agatolio, F., Menegatti, E., & Moro, M. (2018). Il progetto eCraft2Learn: Fabbricazione Digitale e Movimento dei. Mondo Digitale.
Abstract. eCraft2Learn is a two years long H2020 European project aimed at exploiting low-cost ICT, do-it-yourself electronics and 3D printing as an effective approach to promote the interest of 13-17 years old students in STEAM. The main objective of the project is the design, prototyping and validation of an ecosystem integrating the mentioned technologies to support the construction of artefacts in a constructionist perspective following the maker movement principles. The paper presents an overview of the initial design premises, of the adopted pedagogical model and of some architectural details.		

<table>
<tr><th>Number</th><th>Publication type (Conference, Demonstration, Journal, Technical report)</th><th>Publication data</th></tr>
<tr><td>2</td><td>Conference</td><td>Agatolio, F., Suero Montero, C., Moro, M., Cavazzini, A., Menegatti, E. (2018). Badges Are Back! - Fostering Self-Assessment during Personalised Learning in Making and Digital Fabrication. EDUROBOTICS 2018, Springer.</td></tr>
<tr><td colspan="3">**Abstract.** Badges have been used in education and leisure activities for a long time. Digital badges in particular have been reported to become a gamification element fostering students' engagement and motivation. In our work, we explore the use of badges during making and digital fabrication as a way to foster personalised learning paths within the eCraft2Learn learning ecosystem. The badge system description and visual representations are provided here, alongside the underlying pedagogical justification.</td></tr>
<tr><td>3</td><td>Conference</td><td>Alimisi, R., Loukatos, D., Zoulias, E., Alimisis, D. (2018) Introducing the making culture in teacher education: the eCraft2Learn project, international Conference Education Robotics, Padua, Italy.</td></tr>
<tr><td colspan="3">**Abstract.** This paper presents the capacity building workshops for teachers that took place in the makerspace established in Athens in the frame of the eCraft2Learn project. The aim of the workshops was to familiarise the teachers with the eCraft2Learn ecosystem that provides tools from robotics, DIY electronics, visual programming, 3D modelling and 3D printing in order to enable them to take on the role of the coach for their students in an environment inspired from the maker movement. The paper presents the training sessions and reports the trainees' feedback focused on the strong and the weak aspects of the eCraft2Learn tools, the challenges they faced, their understanding of the pedagogical ideas underpinning the eCraft2Learn initiative, and finally their confidence and preparedness for their role as coach.</td></tr>
<tr><td>4</td><td>Technical report</td><td>Alimisi, R., Papasarantoua, C., Loukatosa, D., and Zouliasa, E. (2018) The eCraft2Learn workshops: putting forward an open craft and project based methodology for computer-supported artefact construction. Technical report.</td></tr>
<tr><td colspan="3">**Abstract.** In many cases, new technologies are simply reinforcing old ways of 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. 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.</td></tr>
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<tr><th>Number</th><th>Publication type (Conference, Demonstration, Journal, Technical report)</th><th>Publication data</th></tr>
<tr><td>5</td><td>Conference</td><td>Alimisis, D., & Loukatos, D. STEM education post-graduate students’ training in the eCraft2Learn ecosystem. In Proceedings of the 2nd International Conference on Innovating STEM Education, Athens, 2018 (in press)</td></tr>
<tr><td colspan="3">Abstract. The eCraft2Learn research project aims to introduce digital fabrication and maker movement in formal and informal education settings. In the context of the eCraft2Learn pilots we organised during the academic year 2017-18 two experimental sessions of six hours each in the eCraft2Learn lab for student-teachers who attend the post-graduate course STEM Education. This paper reports the educational methodology and the technologies used in the experimental sessions, the projects that trainees first observed being developed by the young students and then realised by themselves, and finally the evaluation of this intervention through trainees’ reports and the “homework” assigned to them.</td></tr>
<tr><td>6</td><td>Conference</td><td>Asimakopoulos, K., Zoulias, E., Saranteas, I., Makaris, I., Sandali, G., & Spiliou, T. The eCraft2Learn project in 1st EPAL KORYDALLOS: integrating a FabLab in the school curriculum. In proceedings of the 11th Pan-Hellenic and International Conference "ICT in Education", 2018 (in press)</td></tr>
<tr><td colspan="3">Abstract. Digital technology is radically changing the way people work in industry, finance, services, media and commerce. At the same time, schools are in difficulty to promote this knowledge due to the lack of the pedagogical models on how to apply new technology into teaching in a meaningful way. This work is a part of the implementation in formal education of a Horizon 2020 project called eCraft2Learn. The 1st EPAL KORYDALLOS implemented a part of the project in a FabLab in its facilities. In this work the methodology that was applied is based on, the Constructivist learning by making methodology that is strongly related to the do-it-yourself (DIY) philosophy. The main goal, for twenty-nine students, was to come up with solutions in engineering problems reinforcing personalised learning and teaching in science, technology, engineering, arts and math (STEAM) education.</td></tr>
<tr><td>7</td><td>Conference Demonstration</td><td>Kahn, K. (2018) Interpolating (and extrapolating) 3D turtle programs in Beetle Blocks. Constructionism Conference 2018.</td></tr>
<tr><td colspan="3">Abstract (Demonstration). Turtle programs can be treated as objects to manipulate. In this demo a program takes two turtle programs as input and creates a new program that is the interpolation between the input programs. An input of .25, for example, will behave like one-fourth of the first program and three-fourths of the second. An input greater than 1 will extrapolate beyond the second program in the direction from the first program. This idea was explored in (Kahn 2007) for two-dimensional turtle programs. Here we generalise it for Beetle Blocks (Romagosa et al 2016), a 3D version of Snap! (Harvey & Mönig 2010).</td></tr>
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<tr><th>Number</th><th>Publication type (Conference, Demonstration, Journal, Technical report)</th><th>Publication data</th></tr>
<tr><td>8</td><td>Conference Workshop</td><td>Kahn, K. (2018) AI Programming in Snap!, Workshop in Constructionism Conference 2018.</td></tr>
<tr><td colspan="3">Abstract. We have added new blocks to Snap! for speech synthesis, speech recognition, image recognition, and machine learning. These run in a Chrome browser without any extensions or installation. An interactive guide has been developed. Twelve sample programs are available. During the workshop participants will explore these new blocks. They will have the opportunity to modify the sample programs. Familiarity with Snap! or Scratch will be very helpful but not absolutely necessary. While this software can run on tablets and smartphones we recommend you bring a laptop.</td></tr>
<tr><td>9</td><td>Conference</td><td>Kahn, K., Megasari, R., Piantari, E., & Junaeti, E. (2018). AI programming by children using Snap! block programming in a developing country.</td></tr>
<tr><td colspan="3">Abstract. The development of human civilization today can’t be separated from the Artificial Intelligence. To prepare for this, early education on Artificial intelligent should be done. Some activities have been done to support students making AI programs, for example Google AIY, Machine Learning for Kids website, the Wolfram Language, and the eCraft2Learn project. One of the new block programming languages Snap! has been extended to provide an easy-to-use interface that provides AI cloud services as well as other AI functions. However, there is little research about AI programming learning for children in developing countries. This paper presents how the learning of AI programming using Snap! programming in Indonesia. The learning process was evaluated with 40 Senior High Schools and Vocational students. 84% students had some basic programming experience but others had none. 70% students who had basic programming experience felt that AI programming using Snap! was easy to understand, yet the students with no programming experience found it difficult. Even though mostly the students can answer the evaluation question about how AI works and all the students were keen on creating AI programs using Snap!. We concluded that Snap! programing worked to introduce AI to children and has encouraged children to explore AI programming. However, some improvements are required to improve the learning process of AI programing using Snap! in developing country. The improvements are presented in this paper as the result of this research.</td></tr>
<tr><td>10</td><td>Conference Workshop</td><td>Kahn, K., Suero Montero, C., & Voigt, C. (2018, June). STEAM learning in formal and informal settings via craft and maker projects. In Proceedings of the 17th ACM Conference on Interaction Design and Children (pp. 728-733). ACM.</td></tr>
<tr><td colspan="3">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.</td></tr>
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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.		
11	Conference	Kahn, K., & Winters, N. (2018) AI Programming by Children. Constructionism Conference 2018.
Abstract. The idea of children constructing artificial intelligence programs goes back to the early days of Logo (Papert & Solomon 1971; Kahn 1975; Kahn 1977). After decades of little activity recent efforts to support students in making AI programs has come from Stephen Wolfram (Wolfram 2017b), Google (Google 2018a, 2018b), the Machine Learning for Kids website (Lane 2018), and the eCraft2Learn project (eCraft2Learn 2018b). Two technological developments underlie the feasibility of these efforts: (1) AI cloud services and (2) mainstream laptops and desktop computers that now can run sophisticated machine learning algorithms. And all of these developments can be made accessible in a web browser, thereby running on many platforms without the need to install software. Given appropriate programming tools children can make apps and intelligent robots that rely upon speech and image recognition services. They can add custom capabilities to their programs by using machine learning training and prediction. In doing so they may learn about perception, language, psychology, and the latest empowering technologies. We describe the addition of new programming blocks to the Snap! visual programming language (Harvey & Mönig 2010) that provide easy-to-use interfaces to both AI cloud services and deep learning functionality. Interactive learning materials have been developed and preliminarily trialled with students. We anticipate in future trials to observe children creatively using these new blocks to build very impressive programs. Children are likely to be even more motivated to program when the results are such capable programs.		
12	Conference	Kahn, K., & Winters, N. (2017, September). Child-friendly programming interfaces to AI cloud services. In European Conference on Technology Enhanced Learning (pp. 566-570). Springer, Cham.

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Abstract. AI cloud services are available for speech synthesis, speech recognition, image and video recognition, text analysis, and machine learning. School students could use these services in a wide variety of programming projects including voice commands to robots, chatbots, audio games, and vision-based robotics. In doing so they may learn about perception, language, psychology, and the latest empowering technologies. A major obstacle to using these services in schools is that they are technically complex APIs beyond the ability of most school students. The challenge addressed in this paper is how to provide interfaces that are much easier to use and yet still supports most of the functionality of these AI services. We describe the addition of new programming blocks to the Snap! visual programming language [1] that provide easy-to-use interfaces to these services. We have developed new blocks for speech input and output and image recognition. Learning materials have been developed and preliminarily trialed with a small number of children.		
13	Conference	Loukatos, D., Kahn, K., Alimisis, D. Flexible Techniques for Fast Developing and Remotely Controlling DIY Robots, with AI flavor. Edurobotics 2018 Conference, Rome, Italy, October 2018.
Abstract. During the last years we are witnessing a very successful osmosis between innovative and cost-effective credit card - sized computers and education. These computers, equipped with low cost sensors or actuators, can be the "heart" of various DIY robotic artefacts. This environment allows for a mixture of thinking and making activities that can be very meaningful in terms of pedagogy and science. Indeed, similar practices, usually referred as STEM or STEAM activities, are applied in many educational institutions, from primary schools up to universities, with most of the effort to focus on secondary school students. The overall process, although promising at the beginning, is not always straightforward to keep up with. More specifically, as students get more experience, they develop a hunger for more complicated scenarios that usually demand features like remote interaction with simple Artificial Intelligence – A.I. capabilities or sophisticated control of their robotic artefacts. At this moment, trainers should be able to propose simple and stable techniques to their students for implementing such features in their constructions. This paper proposes flexible methods for this to be done by exploiting the very popular MIT App Inventor and Snap! visual programming environments, in conjunction with a modified tiny web server module, written in Python, that runs on a Raspberry Pi credit card - sized computer. Furthermore, this paper reports on simple techniques being used to make robust enough robots by low cost everyday / recyclable materials like cardboard, wood, plastic bottles or broken toys.		

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14	Conference Workshop	Suero Montero, C. (2018). Craft- and Project-based Making for STEAM Learning. 18th Koli Calling International Conference on Computing Education Research, pre-conference workshop.
Abstract. Science, technology, engineering, arts and math (STEAM) learning is a promising way to engage learners, both males and females in the process of inquiry in order to become active makers, designers and innovators. A learning ecosystem that integrates a suitable pedagogical approach as well as technological tools could facilitate this process. This workshop includes presentations by the eCraft2Learn project funded by the European Union's Horizon 2020 Framework, keynote speakers Sylvia Martinez and Gary Stager as well as interventions from the participant researchers and teachers. During the workshop, we will explore the idea of fostering the link between sciences, technology, engineering, and math with arts, in order to encourage the inclusive participation of students with all levels of technical skills and also to reduce the technology-triggered gender divide. The eCraft2Learn learning ecosystem will be described from its pedagogical underpinnings to the technical implementations that support the pedagogical approach including a unified user interface and a large set of tools for ideation, planning, creating, programming, and sharing. Within the eCraft2Learn learning ecosystem, support has been developed to enable children to create AI programs that rely upon cloud services [1], to assist teachers in their role as coaches through learning analytics [2] [3], and to foster personalised learning paths and self-reflection and regulation through a badge system and gamification. Results from pilot studies will be shared. Presentations from participating international researchers that are working on making for learning will take place, as well as hands-on activities and demonstrations involving the entire audience.		
15 ok	Conference	Suero Montero, C. (2018). Facilitating Computational Thinking through Digital Fabrication. 18th Koli Calling International Conference on Computing Education Research.
Abstract. Curricular changes towards fostering computational thinking through programming activities for students of all ages are spreading rapidly throughout Europe. However, students may be negatively biased or not interested or prepared to engage in such activities. This work proposes digital fabrication within a hands-on pedagogical frame as an approach to engage students in programming activities facilitating the use and understanding of computational thinking concepts. Within the proposed approach, students engage in programming applied to develop tasks from their school curriculum. This paper illustrates the approach through pilot trial experiences at a local junior high school.		

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16 ok	Conference	Suero Montero, C., Voigt, C., Mäkitalo, K. (2018). From Digital Fabrication to Meaningful Creations: Pedagogical Perspectives. EDUROBOTICS 2018, Springer.
Abstract. Digital fabrication consists in a range of techniques used to create products from digital designs. For the development of the digital citizen, digital literacy is a fundamental skill. However, the current education system widely used is heavily reliant on traditional education methods and activities or use technology to promote old ways instead of innovative thinking. In this work, we look at pedagogical approaches that facilitate the intake of technology to be used in educational contexts. First, we present our inquiry and design thinking based approach that encompasses five stages: ideation, planning, creation, programming and sharing to imbue digital fabrication with meaningful creations. The paper continues to present students' work and provides a summary feedback from teachers. We conclude by arguing that teaching approaches and learning stages are good to structure learning through digital fabrication ex-ante, but that there is a need to also support the experiential dimension on the teachers' side to make it work by acquiring a 'coach's mindset', following students' ideas.		
17	Conference	Toivonen, T., Jormanainen, I., Suero Montero, C., & Alessandrini, A. (2018). Innovative Maker Movement Platform for K-12 Education as a Smart Learning Environment. In Challenges and Solutions in Smart Learning (pp. 61-66). Springer, Singapore.
Abstract. The growth of the maker movement has created a demand to include tools for digital fabrication in the school curriculum to foster STEAM education. Yet, the tools used by the maker movement remain sparse and do not exist integrated in the same environment for educational purposes. In this paper, we introduce a smart learning environment that collects the tools of design, 3D-printing, programming, sharing and data analytics into the single frame where K-12 level students and their educators can make maker movement artefacts while enhancing their STEAM skills. Our developed smart learning environment gathers data from the users' digital trails and analyzes these data with several white-box data mining algorithms in order to support the educators' interventions in the making activities carried out in the classroom.		
18	Conference	Voigt, C. (2018, May). Not Every Remix is an Innovation: A Network Perspective on the 3D-Printing Community. In Proceedings of the 10th ACM Conference on Web Science (pp. 153-161). ACM.
Abstract. A better understanding of how information in networks is reused or mixed, has the potential to significantly contribute to the way value is exchanged under a market- or commons-based paradigm. Data as collaborative commons, distributed under creative commons licenses, can generate novel business models and significantly spur the continuing development of the knowledge society. However, looking at data reuse		

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in a large 3d-printing community, we show that the remixing of existing 3d models is substantially influenced by bots, customizers and self-referential designs. Linking these phenomena to a more fine-grained understanding of the process and product dimensions of innovations, we conclude that remixing patterns cannot be taken as direct indicators of innovative behavior on sharing platforms. A further exploration of remixing networks in terms of their topological characteristics is suggested as a way forward. For the empirical underpinning of our arguments, we analyzed 893,383 three-dimensional designs shared by 193,254 members.		
19	Conference	Voigt, C., Mair, S., & Unterfrauner, E. (2018, October). Hacking the knowledge of maker communities in support of 21st century education. In International Conference on Internet Science (pp. 286-299). Springer, Cham.
Abstract. The paper addresses the need to rethink education to be effective in a changing environment. More concretely we look at the intersection of craft-based learning, digital fabrication technologies and schools' capacities to absorb educational innovations. Although making and hacking are known activities within constructionist learning settings, they are not yet widespread at a school level. An explorative study of maker education across European countries has shown that a major impediment to innovations, such as digital fabrication in schools, were the perceived complexity of the process, the technical skills required and the lack of easily accessible resources for getting started or being able to troubleshoot if needed. The aim of this paper is to test the possibilities of referencing existing knowledge embedded in platforms such as instructables.com. Using the available API, we created a network graph of 225,681 instructables authored by 74,824 authors. The potential of that knowledge base is analysed in two steps: first, we describe the available content on the platform in terms of topics, structure and licenses and second, we explore the value of topic networks, as one specific possibility to make platform knowledge more accessible to educators and learners themselves. A first prototype has been implemented and evaluated, showing the importance of discussing the value and limitations of resources external to educational systems, learning by doing, accountability and the right to tinker in technology-embedded teaching.		
20 ok	Conference	Voigt, C., Schön, S., & Hofer, M. (2018). Innovation management in schools: Barriers and enablers to making as educative practice. Multikonferenz Wirtschaftsinformatik (MKWI).
Abstract. This paper explores the use of maker technologies as activities embedded in a wider educational ecosystem. Innovations are generally described as the exploitation of new ideas; hence novel technologies and processes need to be adopted by the relevant user groups. The paper starts with a conceptual overview of maker technologies, innovation types and highlights the special situation of educational quasi-markets, where innovation management is different to fully competitive markets, such as the hardware and software		

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industry. At the core of the paper are teachers' perceptions of barriers and enablers to using novel technologies. Assuming a systemic perspective on innovations, the paper also discusses topics such as appropriate funding, national regulations, curricular flexibility, technologies ready to use and adequate training opportunities for teachers. Hence, first findings of a research project on making and innovation management in schools are presented on the basis of 25 interviews from nine European countries.		

3 CONCLUSION

The ambition of the eCraft2Learn project has been to provide open access to the published scientific results in conferences and journals. In addition, in order to increase the impact of the research, organized workshops and other scientific activities have been carried out. Considering the length of the project, both with respect to quantity and quality the output of the project with respect to publications is quite satisfactory. There is still progress regarding overall improvement of the educational extension as well as individual services/applications that will generate further publications in the near future.

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[8] Kahn, K. (2018) AI Programming in Snap!, Workshop in Constructionism Conference 2018.

[9] Kahn, K., Megasari, R., Piantari, E., & Junaeti, E. (2018). AI programming by children using Snap! block programming in a developing country.

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[12] Kahn, K., & Winters, N. (2017, September). Child-friendly programming interfaces to AI cloud services. In European Conference on Technology Enhanced Learning (pp. 566-570). Springer, Cham.

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[18] Voigt, C. (2018, May). Not Every Remix is an Innovation: A Network Perspective on the 3D-Printing Community. In Proceedings of the 10th ACM Conference on Web Science (pp. 153-161). ACM.

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