Fab Labs / Makerspaces & Academia
Fab101 Literature Review

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Remaining questions regarding fab101

?? all clear?

Research strategy

- Google Scholar
- **Keywords:** Fablab role in Higher education, Fablab enhancing Curriculum, Fablab in Education, Makerspaces at Universities, Design Education, Makerspace in Education, the impact of makerspace, Fab Lab access managment , Fab Lab roles, Fab Lab managment
- Links
- Usually find interesting papers in the references of the paper that I finished reading and just google the name

Which Disciplines are dealing with research on Fab Labs / Maker Movement?

Different type of disciplines are dealing with Fab Labs, like:

Discipline (of the paper!!)	Research Paper	University
Engineering and Applied Science	Academic Makerspaces and Engineering Design	Yale University
Proceedings of the Technology Education Research Conference on Best Practice in Technology, Design and Engineering Education	Changing the emphasis of learning through making in Technology education	Griffith University
In Faculty of Industrial Design Engineering. School of Communication, Media, and Information Technology. Sustainable Solutions course.	FabLab in Design Education	University of Applied Sciences University of Technology
Mechanical engineering Proceedings of the ASME 2016 IMECE	Higher Education Makerspaces and Engineering Education	Yale University

art and design, engineering, and liberal arts International Journal of Technology and Design Education	If you build it, will they come? Student preferences for Makerspace environments in higher education	Arizona State University Carnegie Mellon University University of Texas University of North Carolina
Study STEM student self-confidence in education, and the impact of the fablab positively of the students confidence Journal of STEM Education	Impact of fab lab Tulsa on student self-efficiency toward STEM Education	University of Oklahoma Fab Lab Tulsa Hardesty Family Foundation
Master Thesis in Product Development	Makerspaces in the University Community	Technische Universität München
different disciplines	The NMC Horizon Report 2015: library edition-(Makerspaces) P.36-P.37	The new media consortium nmc.org
Article in “The Chronicle of Higher Education” (non academic journal)	The Maker Movement Goes to College	He studied multiple cases in different universities
eLearning Papers Education / learning	The Maker Movement. Implications of new digital gadgets, fabrication tools and spaces for creative learning and teaching	Innovation Lab, Salzburg Austria Graz University of Technology Austria College of Education, University of Florida
Engineering Education	The Promise of the Maker Movement for Education	The researcher came from University of California-Davis
Engineering Masters Degrees and PhD level.	Design and Innovation Learning: Case Study in North African Engineering Universities Using Creativity Workshops and Fabrication Laboratories	Seven North African Universities

<u>Where do people publish?</u>

- Which Journals
- Which conferences
- ToDo?

<u>What are relevant theories and (research) methodologies mentioned in the papers?</u>

… (e.g. constructionism, design thinking, participatory innovation, etc)

Research Paper	Research methodologies used	Theories / theoretical approaches
FabLab in Design Education	Experiment : by creating a new elective course Observe the field: the improvements and reactions of the students Do analysis of the results 'agile rapid prototyping' Agile design processes co-creation	- Design Thinking (Tim Brown)
Higher Education Makerspaces and Engineering Education	They provide methodologies to encourage design thinking in the mechanical engineering practical lab And then analysing the results of members who participated in the course and the impact on them.	
If you build it, will they come? Student preferences for Makerspace environments in higher education	They surveyed 276 students from art and design, engineering, and liberal arts majors to better understand their preferences as related to images of eight different Makerspaces.	
Impact of fab lab Tulsa on student self-efficiency toward STEM Education	They did meta analysis from the previous researches in the same field and survey among the participant students.	
Makerspaces in the University Community	Analysis of Meta analysis from other universities,	

	lessons about different forms of implementing prototyping into the curriculum using makerspaces and how they affect student life of technical students at the university can be learned.	
The Maker Movement. Implications of new digital gadgets, fabrication tools and spaces for creative learning and teaching	Constructivist method was used.	
The Promise of the Maker Movement for Education	Constructivist method and Meta Analysis	
Design and Innovation Learning: Case Study in North African Engineering Universities Using Creativity Workshops and Fabrication Laboratories	Experiment : by creating a new elective course for Engineering students and through two other events “Egg’s Drop Game”, “Golden Egg” and International Innovational Week. Quantitative Results that came out of the events and the courses.	
Strategic knowledge management a digital environment: Tacit and explicit knowledge in Fab Labs	Interviews with seven Fab Lab managers from their LinkedIn connections.	
BENDING THE RULES: THE FAB LAB INNOVATION ECOLOGY	Nine Fab Labs have been analysed	
Diversity in FabLabs:Culture, Role Models and the Gendering of Making	Interviewing makers, a multi-case study of 10 different make spaces. Analysis of one of the FabLabs anonymised machine logs, including demographics of members since 2010, machine use statistics since 2012 as well as the type of membership chosen by each member during this time	

FabLab – a new space for commons-based peer production(HAL)	series of interviews they conducted between January and April 2017 with Fab Managers from the Paris area and other regions in France	
Participatory design and participatory making in a FabLab: challenges for users and designers	Participatory Design (PD), involving end-users as full participants in the design process	

Publications dealing with fab lab infrastructures & support systems:

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  - access control systems,
  - machine management, machine lists,
  - learning progress monitoring systems,
  - project documentation systems
  - finance / organization models for makerspaces and fab lab
  - etc

1.Fablabs in Design Education (Mostert-Van Der Sar et al -2013):

The paper displays from an educational perspective the structure of an academic course that has been given and added in Design Education, as well presenting the process of rapid prototyping and the Communications between the students from brainstorming until having an actual prototype to represent their accelerated idea.

Authors:
Peter Troxier: he received a Dr. sc. techn. in Management, Technology and Economics, and an MSc. in Industrial Engineering, both from ETH Zurich, and a certificate in International Copyright Law from the University of Amsterdam. He received formal training in online journalism, in educational video production, as a facilitator for Local Agenda 21 and for future workshops, and in sound engineering.
Currently, his main focus is investigating and developing business models of open source anything – design, hardware, inventions – and the corresponding formats and ecologies of innovation and co-creation.

Manon Mostert - van der S.: holds a Bachelor degree in Experience Branding from Hogeschool Rotterdam work as producent at Stadslab Rotterdam and as a researcher for Creating 010. Next to that I lecture Fablab 'How to make almost anything'. And own an creative company named '& Sar' (Studio van der Sar).

Leo Remijn: He is senior lecturer in Media Technology. And he is responsible for the development and embedding of the sensor lab (part of the City Lab) in education. Within the knowledge center he is doing research on Human Centered Computing.

Dr. Ingrid Mulder: she is an Associate Professor in Industrial Design, and an expert in transformative and social design. As part of her previous readership in Rotterdam, she has initiated the first Fablab in Rotterdam as well as the Rotterdam Open Data movement. She also founded Creating010, a trans-disciplinary design-inclusive research centre enabling citizens, students, and creative industry making the future of Rotterdam. Since 2007 she chairs the research program Meaningful Design in the Connected City, which connects research and education in both Delft and

Rotterdam. Her background is in Policy and Organization Sciences (MA, University of Tilburg) and Behavioral Sciences (PhD, University of Twente). In 2005, she headed the evaluation of the first Dutch living lab, “Kenniswijk”, currently known as Brainport Eindhoven. Ever since, she has been involved in the interplay between top-down policy and planning with bottom- up participatory innovation. As an expert for the European Commission on Internet of Things and Smart Cities, she advocates participatory bottom-up innovation as a means to empower people in driving social change.

2.The Maker Movement. Implications of new digital gadgets, fabrication tools and spaces for creative learning and teaching (Schön et al - 2014):

This paper gives insights from an educational perspective into the background, practice and existing experiences from Maker Movement in educational settings amongst all age groups and shows the differences between traditional teaching and the Makers Education.

Authors:

Sandra Schön: studied educational science, psychology and computer science at the Ludwig-Maximilians-University in Munich. For her master degree (M.A., Magister Artium), she worked on online assessment in vocational further education. During and after Sandra’s studies she worked at the German Youth Institute in Munich about Children and the Internet. Before joining the EduMedia group at Salzburg Research in 2006, she was a researcher and trainer in a private training company. In 2007, Sandra received her PhD (Dr. phil., magna cum laude) with an empirical analysis of learning activities with vocational relevance at the Ludwig-Maximilians-University in Munich (Prof. Dr. R. Tippelt).

Sandra’s research interest lies learning with new technologies and innovative approaches, taking into consideration developments such as open educational resources, the e-portfolio method and new cooperative learning settings. Especially within her work for the Salzburg New MediaLab she additionally works in the field of online communities, e.g. on reputation systems and the usage of user generated content and informations

Martin Ebner: is an Assistant Professor at the Institute for Building Informatics (IBI) at Graz University of Technology, in Austria. He has a M.Sc. (Dipl. Ing.) in Civil Engineering and Ph.D. in Technical Sciences from Graz University of Technology. His research is in the area of e-Learning and Web Communities with a strong emphasis on civil engineering. A number of international publications and presentation to these topics has been given. Martin is member of the national research groups “Forum Neue Medien Austria” and “Human-Computer-Interaction & Usability Engineering”.

Swapna Kumar: Clinical Associate Professor, Educational Technology,School of Teaching and Learning, Her research focuses on the integration of technology for teaching and learning in higher education. her interests include 1) the design, implementation, facilitation and evaluation of online professional programs 2) online mentoring and 3) open online education.

3.NMC horizon report (Hochschule für Technik und Wirtschaft - 2015):

The Report helps in building a curriculum for Academic and Research Libraries from an educational perspective, and talks about Makerspaces as one of the important developments in technology as well the combination between Student Makers and business and how they can launch their own products and be entrepreneurs and it lists a number of Makerspaces that have direct implications for academic and research libraries.

4.Makerspaces in the university community (Weinmann - 2014):

The paper takes the perspective of education to identify the role of the makerspaces in universities and makes an analysis of other makerspaces at different universities after having qualitative interviews in the research as a method, so later on it evaluate the needs of the Technical University of Munich and develop of concepts for it.

Authors:

Julian Weinmann: Studied Mechanical Engineering at the Technical University Munich (TUM). His majors are in Product Development and Economics. He graduated from the entrepreneurial qualification program Manage & More at the Center for Innovation and Business at the TUM (UnternehmerTUM). There he worked on different projects like a stepless door break for BMW and a human resources project that involved engaging the next generation engineers for Knorr-Bremse. He is also in the process of starting his own company, Probino, with 3 co-founders. Probino is an at-home wine seminar, that teaches beginners about wine through hands-on experience. In addition, Julian has worked at BMW in the Innovation Management group and at a Munich Startup called Payworks.

5.If you build it, will they come? Student preferences for Makerspace environments in higher education (Hynes, Morgan M. - 2017):

This paper takes the perspective of Design by studying makerspaces in higher education as the main objective while addressing multiple makerspaces in different universities and how each university defines its makerspace, also it focuses on the design of different spaces, the study surveyed multiple students from different majors to have a clearer image about the spaces.

Authors:

Morgan M. Hynes: he is an Assistant Professor and he conducts engineering education research in both pre-college and college settings. Morgan's main research interest relates to broadening participation in engineering, which he is pursuing through his NSF CAREER award (2015). His research investigates how presenting engineering in broad, humanistic contexts can appeal to a more diverse population of students. He also investigates how these broad contexts support students' engagement in authentic engineering design practices. Additionally, Morgan explores how Makerspaces or Fabrication lab spaces can help facilitate engineering teaching and learning.

Wendy J. Hynes: is an Assistant Professor and received an M.S. in Architecture from the University of Michigan and a B.S. in Interior Design from the University of Wisconsin-Madison. She is coming to Purdue after leading the interior design efforts at a Boston-based architectural firm for the last 8 years. Previous academic appointments include Assistant Professor of Interior Design at Ball State University and Lecturer of Interior Architecture at the University of Wisconsin-Stevens Point. She has also had the opportunity to teach at the Boston Architectural College and New England School of Art and Design.
Her research interests include creating restorative experiences in the built environment, taking certain features of nature and recreating them abstractly to replenish one's directed attention or ability to focus. She is most interested in the types of built environments that are among the most stressful, including school and the workplace.

6.Impact of Fab Lab Tulsa on Student Self-efficacy Toward STEM Education (Dubriwny et al - 2016):

This study shows the fab lab impact on students self-confidence in STEM education from the perspective of education, based on two goals, the impact of Fab Lab Tulsa programs on the self-efficacy of school-aged children, and the correlations between self-efficacy, attitudes toward STEM, perceived impact, and skill attainment among participating students, this study could be helpful to examine the impact of fab lab in Education in General not only in STEM.

Authors:

Nicholas Dubriwny: Nicholas Dubriwny, LCSW is a social worker in Tulsa, OK. He specializes in social work and clinical social work.

Nathan Pritchett: Executive Director of the Hardesty Center for Fab Lab Tulsa.
Nathan is a technologist and futurist, guiding the organization's vision of digital fabrication and maker culture, as well as targeted outreach programs in STEM education, community capacity building and entrepreneurship development. He holds a Master of Science degree, serves on the Tulsa Regional Chamber of Commerce's Manufactures' Council

Michele Hardesty: is an assistant professor of U.S. literatures, received her B.A. from the University of Wisconsin-Madison and her Ph.D. from Columbia University, Her teaching and research interests include the 20th century novel, political travel writing, globalization and transnational culture, graphic narrative, media studies, and American studies, She is currently working on a project concerning U.S. writers who traveled to and wrote about conflicts in the "Third World" during the Cold War.

Chan M. Hellman: he is a Professor in the Anne & Henry Zarrow School of Social Work and Founding Director of the Center of Applied Research for Nonprofit Organizations. He is also an Adjunct Professor in the Departments of Internal Medicine and Pediatrics for the OU College of Medicine and Department of Health Promotion Sciences for the OU College of Public Health. Chan's current research focuses on the application of hope theory. In particular, he is interested in how nonprofit organizations impact client hope and how hope is associated with positive goal attainment and well being among those experiencing adversity and stress (e.g., child maltreatment, homeless, domestic violence, substance abuse)

7.The makers' movement and FabLabs in education: experiences, technologies, and research (Blikstein, Krannich - 2013):

The paper discusses how to implement, research and develop digital fabrication and making in Schools, based on research papers and experiences in formal and informal education and the challenges in community building, which is basically an educational perspective.

Authors:

Dannis Krannich: is Senior Researcher of the work group Digital Media in Education (dimeb) at the University Bremen, Germany, and a leading expert on digital media and digital fabrication in education.He is head of the digital experience lab at University Bremen and deputy chairman of FabLab Bremen. His research focuses on the mergence of the physical and digital world. In particular he investigates the influences of personal fabrication on HCI to bridge the gap between analysis and design, and on how to learn with and about personal fabrication ("be-greifbare Interaktion"). Dr. Krannich is a lecturer within the Digital Media and Informatics department. He is member of German UPA and TZI (Technologie-Zentrum Informatik und Informationstechnik).

Paulo Blikstein: He is an assistant professor at the Stanford University Graduate School of Education where he directs the Transformative Learning Technologies Lab and the global FabLearn Program. He's research focuses on how new technologies can deeply transform the learning of science, technology, engineering, and mathematics.Blikstein was a pioneer in bringing the maker movement to schools, and started the first educational program around digital fabrication in schools, FabLearn Labs (formerly FabLab@School). His group has built advanced digital fabrication labs and has conducted research in middle and high-schools in the US, Russia, Mexico, Spain, Australia, Finland, Brazil, Denmark, and Thailand.

8.The Promise of the Maker Movement for Education (Martin - 2015):

This paper shows from educational perspective, the physical tools of the maker-spaces and how helpful they are for education and rapid prototyping, and another two elements that are necessary to understand is community infrastructure and the maker mindset, also how making could be playful, and also address the Failure-Positive and how it could benefit, also the reasons why Making is valuable learning activity.

Authors:
Lee Martin: studies people's efforts to enhance their own learning environments, with a particular focus on mathematical thinking and learning. In everyday settings, he looks at the varied ways in which people assemble social, material, and intellectual resources for problem solving and learning. In school settings, he looks to find ways in which schools might better prepare students to be more resourceful and flexible in fostering their own learning. An interesting report about him can be found here:
https://www.comstocksmag.com/web-only/uc-davis-beta-lab-studies-maker-movement-youth

9.Changing the emphasis of learning through making in Technology Education:

This paper tries to make the connection between the user and the object to improve the life cycle of the object as the user is more likely to maintain the object this is basically from two perspectives the first one is education and the second one is from innovation, increasing its lifespan and improving its embodied energy. This theory has been applied to five methods, first empowering the user -where it began in MIT FabLab- to improve the understanding of the working and production of objects.And second "Learning through making" was the second application for better connection and it has been taking part in education since the 20th century, like the fourth method "learning through making" things that happen in schools in technology education through learning from trial and error. Students are required to execute the making of design models in resistant materials such as wood and metal. The workshop and the classroom are completely separated realms, where design development is undertaken in the design stages only and this separation develops their understanding by connecting with the object. And the last practice has been done with students is to predict how the material will behave in reality and what are the challenges of working specific processes will actually bring. And the fourth method depends on that students need to feel like home in the workshops so they can be more productive, and in order to do this, students should be introduced to tools and materials as early as possible. The last method is using assessment tools for changing practice, where students learn about how materials react when manipulated based on research theory is akin to teaching someone to learn to swim in a classroom, so the time in workshops should be increased and promote a ‘culture of making’ within the students.

Authour:

Sam Canning: is a lecturer into the Digital Media and Industrial Design programs at Griffith on the Gold Coast campus, On leaving school Sam trained as a French Polisher specialising in antique restoration using hand polishing using only traditional methods, He made furniture for a number of years before coming to Australia. During this time Sam developed an interest in CNC machining and its potential for craft practice.
Sam studied Industrial Design at QUT 2001-2003 after which worked for Brisbane based Industrial Design consultancy CMD, He Began working at QCA as a sessional staff member in 2007 switching to full time in 2015. PhD student from 2012 researching 3D Printing and its potential for craft practitioners.
Sam is currently interested in learning through making and the blending of traditional craft knowledge and new technologies.

Jennifer Loy: She’s holding a PhD in Industrial Design. Scholarship from Department of Primary Industries and Fisheries, CRC Wood Innovations, National Institute of Design, Swinburne University. And Master of Arts in Textile and Product Design. Manchester Metropolitan University & Liverpool John Moores Uni, UK. She got her Bachelor of Arts Hons (Furniture Design). Nottingham Trent University, UK.
Her motivation is that she’s doing Postgraduate Certificate in Teaching and Learning in Higher Education.

10. Higher Education Makerspaces and Engineering Education

This paper focus educational and innovational perspective, it reviews the history of the maker-phenomenon, details the development of the higher education makerspace cultures over the past years and explores the impact of makerspace cultures on mechanical engineering education. It sees makerspace as a community of members who use the facility and the activities of the community. The first fab-lab creation was in MIT class (“how to make almost anything”) in 1998. In 2001 MIT center for Bits and Atoms explores the creation of physical objects from digital representation, and the training in the Fab-lab was peer-to-peer to leverage the personal fabrication skills of the members. In the same time there was ‘NYC Resistor’ where it was based on the same concept of the Fab-Lab.
There is a number of different makerspaces the commercial ones, Industrial ones and the community based makerspace. Makerspace in higher education is generally aligned with the concept of active learning, project-based learning, and incorporating design experiences. Students and members interact directly with each other with little oversight or direction provided by the makerspace staff. The impact on the mechanical engineering that it provided a central location that allows students to practice the design skills needed by a mechanical engineer, where student benefit from training on fabrication equipment in this space and then use them in a series of courses. Also, a huge number of courses were added to the curriculum after the CEID -design course for mechanical engineering students in Yale University- was added. Moreover, makerspace helped export design skills into the broader community, where many students start to do start-up businesses used the prototypes developed, as students to launch companies.

Authors:

Ronald Adrezin: he got his Bachelor of Engineering, The Cooper Union, 1986. Master of Engineering, The Cooper Union, 1988. Doctor of Philosophy, Rutgers University, 1997. And now he is professor of Mechanical Engineering at the U.S. Coast Guard Academy in New London, At the Academy, he teaches analysis and design courses. He worked worked primarily in the aerospace and biomedical engineering fields.
An interesting report about 3D experience is attached: https://www.theday.com/article/20150926/NWS09/150929414

Vincent Wilczynski: Dr. Wilczynski holds a B.S. from the U.S. Coast Guard Academy, an M.S. in mechanical engineering from MIT, and a Ph.D. in mechanical engineering from The Catholic University of America. He is the Deputy Dean of the Yale School of Engineering & Applied Science and the James S. Tyler Director of the Yale Center for Engineering Innovation & Design. As the Deputy Dean, he helps plan and implement all academic initiatives at the School. In addition, he manages the School's teaching and research resources and facilities. As the James S. Tyler Director of the Center for Engineering Innovation & Design he leads the School's efforts to promote collaboration, creativity, design and manufacturing activities at Yale's academic makerspace. His professional interests in Mechanical Engineering are in the areas of data acquisition/analysis and mechanical design.

New Researches:

Some papers are highlighted that were used in the references in the previous papers and some were found while searching and interested me.

11. Anderson, C. "Makers: The New Industrial Revolution" which is a very big book but found a very interesting talk for the writer https://vimeo.com/60496236

12. The Maker Movement Goes to College

This paper takes the perspective of education and innovation where it focuses on the concept of "Think[box]" moving from an engineering-building basement, is one of many emerging campus sites open for students to come in and mess around, with the intention that they'll get creative, maybe even hit on something big. The sites go by many names — hackerspaces, innovation centers, Fab Labs — but are generally known as makerspaces and Nebraska's space joins a slew of others in higher education, big and small, already opened or still in the works. Wichita State University recently got nearly $4 million from Koch Industries and the Fred and Mary Koch Foundation to establish an 18,000-square-foot makerspace in a new engineering building opening in 2016. Arizona State University has partnered with TechShop, a private operator of makerspaces, to open a facility. Davidson College, Georgia Tech, Northwestern University, North Carolina State University, Southern Methodist University, and Wheaton College have established makerspaces of various sizes on their campuses. And top-tier research universities like Stanford University and the Massachusetts Institute of Technology are maintaining prominent workshops.

Authors:
Scott Carlson: He is a graduate of the University of Minnesota-Twin Cities, where he studied English literature, with a concentration on contemporary literature and utopian/dystopian literature. He joined The Chronicle of Higher Education in 1999, writes about a range of issues: college management and finance, the cost and value of higher education, buildings, campus planning, energy, architecture, and sustainability.

13. Academic Makerspaces and Engineering Design

In this paper it takes the perspective of design where there was a number of best practices that can be incorporated at existing and planned spaces. The mission of the academic makerspace must be clearly defined from the onset, with the space then designed around that mission. The Stanford Product Realization Lab example illustrates how a traditional machine shop can be adapted to serve as an academic makerspace by hosting courses and creating a self-sustaining culture of users to share information and develop fabrication skills. The example at Rice University illustrates how the physical site can be used to establish a design culture, in this case across nine different majors. To address this issue, the design of the Rice University facility included components to draw in all majors, with the wet lab a key aspect of that plan. Interactions between members of an academic makerspace are the most valuable component of these endeavors. The community of like-minded creators has the potential to fuel itself, with the members teaching each other and serving as resources to spawn new ideas. The operation of the academic makerspace can help create and strengthen this community by offering programming that connects members and eliminate barriers.

Authour:
Vincent Wilczynski: Dr. Wilczynski holds a B.S. from the U.S. Coast Guard Academy, an M.S. in mechanical engineering from MIT, and a Ph.D. in mechanical engineering from The Catholic University of America. He is the Deputy Dean of the Yale School of Engineering & Applied Science and the James S. Tyler Director of the Yale Center for Engineering Innovation & Design. As the Deputy Dean, he helps plan and implement all academic initiatives at the School. In addition, he manages the School's teaching and research resources and facilities. As the James S. Tyler Director of the Center for Engineering Innovation & Design he leads the School's efforts to promote collaboration, creativity, design and manufacturing activities at Yale's academic makerspace. His professional interests in Mechanical Engineering are in the areas of data acquisition/analysis and mechanical design.

14. Research about " Making is Connecting" book

This paper is wonders why Lego brick and the digital brick were invented at the same period in the late 1940s. Both bricks have become generational standards because they have structured the imagination of people who explore today's digital practices. In the believe of David Gauntlett that Making is Connecting, he explained how the three major operations of creativity (making, sharing, and collaboration) are now almost contemporaneous .

Author:
David Gauntlett. Director of Research at Westminster School of Media, Arts and Design. He writes and teaches about the ways in which digital media gives people new opportunities to create and connect, and the social implications of this 'everyday creativity'.
He has also led the development of new approaches to the study of media ('Media Studies 2.0') and pioneered the use of creative research methods in social research.In January 2018 he started a new job at the Faculty of Communication and Design, Ryerson University, Toronto.He has worked with organisations such as the BBC, the British Library, S4C, and Tate. For 12 years he has collaborated with LEGO on creativity and play. He was previously a Lecturer at the University of Leeds (1996-2002) and a Professor at Bournemouth University (2002-2006).

New Papers 10/6

15. Design and Innovation Learning: Case Study in North African Engineering Universities Using Creativity Workshops and Fabrication Laboratories

The Tempus "i-Cré@ Formation" Project (Innovation, Creativity, Action and Training) is a Tempus program of the European commission including seven Maghreb institutions in partnership with eight European institutions, and was completed in January 2013.The main achievements that have been undertaken are along two themes: design and innovation management teachings and FabLab. This goal can be achieved through the teaching of design, innovation management, digital technologies and IT. which included the introduction of new lectures to better address the required innovation and entrepreneurial skills of engineering students. It also included the implementation of innovation platforms according to the Fabrication Laboratory model (FabLab), which enables to set up a clear and complete design process, going from understanding of the problem, creative-solving process, designing innovative ideas and prototyping. A particular attention is paid in this paper to the experience conducted at the National Engineering School of Tunis. setting up new courses in design and innovation in the Maghreb partners, delivered to students in engineering, Masters Degrees and PhD level.

Authors:

Helmi Ben Rejeb: currently works at the Industrial Engineering Department at the École Nationale d'Ingénieurs de Tunis. Helmi does research in Innovation management, User Centred Innovation, Product Design and Fabrication Laboratories (FabLab).

Benoit Roussel: work at GPLUS focuses on 3 areas: EU competition policy, ICT policy and international relations. Benoît joined GPLUS in October 2009 from the European Commission, where he had worked in DG Employment and Social Affairs on EU labour market policies and social funds.Benoît holds a degree in Social Sciences from the Institut d'Etudes Politiques of Bordeaux and the University of Stuttgart, Germany, as well as a Master's degree in European Politics from the College of Europe in Bruges.

Keywords: Fablab role in Higher education, Fablab enhancing Curriculum, Fablab in Education, Makerspaces at Universities.

16. Strategic knowledge management a digital environment: Tacit and explicit knowledge in Fab Labs

There are currently 1241 Fab Labs worldwide, facilitating the sharing of information and knowledge, connecting people and organizations and thus, enabling the collaborative innovation. This paper describes how users learn with others in Fab Labs, where the idea of Fab lab rests on social interaction. They have interviewed seven Fab Lab managers from their LinkedIn connections, the questions that have been asked were interpretative and leading trying to obtain the opinion, experience, and knowledge of the experts interviewed. Some of the results that users check other Makers files for inspiration and users record their projects in their own language for the easiness of the task and all the information should be in English and available on Cloud to allow access to everyone involved.

Authors:

Sérigo Maravilhas : is a post-doctoral researcher at UFBA, Brazil, in Industrial Property and Innovation with a PNPD/CAPES Scholarship (Research Grant). He has a PhD in Information and Communication in Digital Platforms (UA + UP), a Master in Information Management (FEUP and Sheffield University, UK), a Postgraduate Course in ICT (FEUP), a Specialization in Innovation and Technological Entrepreneurship (FEUP and North Carolina State University, USA), and a 5 years Degree in Philosophy, Educational Branch (FLUP). A Teacher and Trainer since 1998, he has worked at ESE - IPP as a Supervisor at the Internet@School project between 2002 and 2005, and a university teacher since 2005 at Aveiro University (DEGEI), and since 2010 at ULP and IESFF in Masters and MBA

levels. Teaches Marketing, Research Methods, Creative Processes in Innovation, Intellectual and Industrial Property, Technology Watch, Information Management, and Organizational Behaviour in universities, and he's a trainer in ICT, Sales, Negotiation, and Neuro-Linguistic Programming (NLP). Publishes and attends conferences mainly in the subjects of patent information, innovation, ICT, marketing, Web 2.0, Webradio, and sustainability.

Joberto Martins: Professor at Salvador University (UNIFACS) and PhD in Computer Science at Université Pierre et Marie Curie - UPMC, Paris (1986). Invited Professor at HTW - Hochschule für Techknik und Wirtschaft des Saarlandes (Germany) since 2003, Senior Research Period at Université of Paris-Saclay in 2016, Salvador University head and researcher at NUPERC (Computer Network Group) and IPQoS (IP QoS Group) research groups on Resource Allocation Models, Bandwidth Allocation Models - BAMs, Software Defined Networking - OpenFlow, Smart Cities, Future Internet, Smart Grid, Autonomic Management, Monitoring, Quality of Service. Previously worked as Invited Professor at Université Paris VI and Institut National des Télécommunications (INT) in France and as key speaker, teacher and invited lecturer in various international congresses and companies in Brazil, US and Europe.

17. BENDING THE RULES: THE FAB LAB INNOVATION ECOLOGY

This paper attempted to examine how commons-based peer production in the physical realm could deal with intellectual property and how Fab Labs could establish business model(s) to develop an innovation ecology. It did so by studying the mechanisms of IP protection and their application and by analyzing existing business models in the innovation ecology of Fab Labs. It proposed a business model for Fab Labs that builds on establishing a commons-based peer production innovation ecology. Value creation in the Fab Lab innovation ecosystem is through two mechanisms, the linking and exchange with a network of partners providing a rich pool of knowledge and experience, and the possibility to quickly and cheaply make things whenever required in the innovation process. Value delivery to customers in the ecology is through time well spent and improving the innovation journey. The Fab Lab captures value by capturing experience and feeding it back into the network.nine Fab Labs from the United States of America, Spain, Iceland, The Netherlands, and Norway were analysed in terms of value proposition, revenue model, processes and resources, marketing, and innovation partnerships.

Authors:

Peter Troxier: he received a Dr. sc. techn. in Management, Technology and Economics, and an MSc. in Industrial Engineering, both from ETH Zurich, and a certificate in International Copyright Law from the University of Amsterdam. He received formal training in online journalism, in educational video production, as a facilitator for Local Agenda 21 and for future workshops, and in sound engineering.
Currently, his main focus is investigating and developing business models of open source anything – design, hardware, inventions – and the corresponding formats and ecologies of innovation and co-creation.

Patricia Wolf: Prof. Patricia Wolf is Professor of Innovation Management and Director of the Creative Living Lab at Lucerne University of Applied Sciences and Arts (Switzerland) as well as Head of Research of the universities Institute of Management and Regional Economics. At the same time, Patricia is Private Lecturer at the Departement of Management, Technology, and Economics at ETH Zurich (Switzerland). Patricia Wolf is Vice President of unBla, a Swiss association concerned with the development and dissemination of unconferencing methods.Patricia Wolf received her master degree in business administration from Technical University of Chemnitz, Germany and her doctor degree in Social Sciences from University of Witten/Herdecke, Germany. Her research focus is on processes of innovation and knowledge transformation in interdisciplinary teams.

18. Diversity in FabLabs:Culture, Role Models and the Gendering of Making

The so-called gender gap is often illustrated referencing the substantially lower numbers of female makers to be found in FabLabs. This paper aims to contribute to the discussion of diversity and inclusion by primarily elaborating gender relations in FabLabs and, to a lesser extent, discussing age and socio-economic conditions of makers. There are four times more male makers than female makers in the first place, a gap that propagates into comparisons for specific machines, getting as high as 10 times more male makers than female makers trying printed circuit board etching. Other than that, both groups are relatively similar in age, female makers have slightly shorter memberships than male makers and are less prone to use 3d-printing or CNC milling machines.Concerning a possible gender gap in FabLabs, the interviews revealed a strong link to early education and the wider presentation of women in tech.
Other than that, one very interesting point is ‘WeMake' FabLab in Milan, which is managed by a female maker, have gender ratios of 40% female makers versus 60% male makers.

Authors:

Christian Voigt: a Senior Lecturer in the School of Mathematics and Statistics at the University of Glasgow. His research area is noncommutative geometry, a modern part of mathematics which has links to classical disciplines like topology, differential geometry and number theory as well as connections with mathematical physics.

Elisabeth Unterfrauner: social scientist and project manager at Centre for Social Innovation, lecturer at the faculty for psychology (Vienna University), Member of Advisory Board at Centre for Social Innovation ,Doctoral Studies at "Lifelong learning Kolleg", summa cum laude; title of dissertation: "Mobile Learning Based Intervention - A Case Study Among Marginalised Young People" and Psychology studies (2004) at Vienna University, summa cum laude: specialisation on learning psychology and psychological assessment.

Roland Stelzer: Everything about him is not in english. (German).

19. FabLab – a new space for commons-based peer production(HAL)

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scienti c research documents, whether they are published or not. The aim of this paper is to shed light on the new type of space and to define the different business models. It is based on a series of interviews they conducted between January and April 2017 with Fab Managers from the Paris area and other regions in France. The analysis by Menichinelli (2015) for which 4 main economic models coexist: (i) The facilitator model; (ii) The educational model; (iii) The incubator model; and (iv) The duplicated network model. In light of our preliminary observations, free, open, MIT-Charter FabLabs generally fall under the category of a model that is both facilitator and educational. Fee-paying FabLabs generally follow an incubator model but also have an educational and training objective. The borders between categories are porous.

Authors:

Isabelle Liotard: is associate professor at the University Paris 13 (CEPN Sorbonne Paris Cité). She is interested in network economy, intellectual property rights (patents) and the Internet. She analyses more specifically firms strategies. She has published few articles on IPR evolution. She collaborates with many legal professionals. At the moment she is working on open innovation, Internet platform, contests and fablab.

20.FabLab Management Platform

They found out that tools which are used by the partners for the management of FabLabs are not as sufficient as they could be. So they identified typical tasks, which are common in every FabLab and Makerspace. They expect an enormous increase of efficiency by supporting the following tasks through using a tailored software solution. In order to find the best possible solution for the deliverable there was a tender offer started for the month of November. The tender was not looking for the development of a new software solution, but an already existing solution that could be adapted to our requirements fast and easy . The objective of the tender was the provision of a „FabLab Management System“ through the contractor that will help with the management of the FabLabs, MakerSpaces, their community and their machine parks.

21.Participatory design and participatory making in a FabLab: challenges for users and designers

They developed bespoke tools for self-managing diabetes specifically related to one person’s everyday experiences. Instead of the strictly medical top-down approaches, combining bespoke designs with PD and self-fabrication is more in line with the fact that people with diabetes use these tools 24/7. Being experts on using these tools they involved three participants with diabetes in the design of bespoke prototypes for each of them. To facilitate re-designing these tools to other people’s wishes and needs, they shared documentation of the prototypes development and conducted these processes in a FabLab.
The project follows the tradition of Participatory Design (PD), involving end-users as full participants in the design process, (potentially) leading to a feeling of shared ownership of the final product. They involved people with type 1 diabetes from the first step of the process, exploring the everyday life with diabetes and ways to self-manage this condition. They extended participation to the making phase; resulting in a process of participatory making. Some important challenges remain : skills and knowledge for using the FabLab infrastructure, providing insights in the value of trial-and-error making processes, can facilitate the involvement of novice participants and using personal fabrication technologies (e.g.3D-printing) is not an easy and quick process for prototyping.

Authors:

Katrien Dreessen: graduated in Communication Sciences at the Vrije Universiteit Brussel on a Master’s thesis concerning an analysis of an online consultation initiative in Flanders, within the context of e-democracy. After working at SMIT research group, she became part of the Social Spaces research group of LUCA School of Arts, located in Genk (BE). She is currently involved in ‘De Andere Markt’ and as coordinator of FabLab Genk, she is very much interested in the wider role of these open makerspaces in society. Katrien also teaches at the communication and media design program of LUCA School of Arts, campus C-mine. Over the years, Katrien was involved in several projects (a.o. Bespoke Design, Mobile Design Lab, FabLabs in the border region, WZC for elderly care, Creating Spaces, Open Garments) that are situated on the intersection of design research, maker culture and/or healthcare. Currently, she is conducting a PhD research on the idea of infrastructuring in FabLabs or how long-term participation of other groups than the traditional makers in these open production spaces can be stimulated and achieved.

Jessica Schoffelen: Jessica Schoffelen is a researcher and lecturer at LUCA School of Arts and associate professor New Media and Interaction Design at KULeuven. She is part of the research group Social Spaces that explores the social qualities of design, art, new media and technologies. Furthermore, she lectures on Art and Design research methods, open design and documentation and is connected to the master programme Interaction Design at LUCA

School of Arts in Genk (BE). In October 2017 she also joined the research group Mintlab, where she explores crossovers and meeting points between social scientific and art and design driven research in the field of HCI. Her PhD (2016) concerned the development of documentation of participatory design projects that aim for long-term participation and self-organisation.

Ollivier Piqueray: His first professional experience was at Kanefas (furniture), where he learned old as well as new techniques of woodwork. In Slovenia, he did an internship at Gigo Design, where he further developed his design experiences. He worked as a designer at the Kringloopwinkel, where he was cofounder of ResourceLab. The project revolves around making designs by sheltered workshop using materials and products that are gather by the Kringloopwinkel. Currently, he's working on a project on the redesign of open tools for self-management for people with diabetes. In his spare time he can be found in his atelier in Antwerp.

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CI, CSCW & Making: Reading Class on FAB101-topics summer term 2017. Topics covered:

- Grounded Design
- Infrastructuring
- The concept of practice
- Education, Bildung, Constructionism & Digital Fabrication

→ Basic Siegen approach & connections to education-focussed digital fabrication

Reading list, papers, presentations & extensive reading notes:
https://drive.google.com/open?id=0ByEOnFPBo2UwYkNBRzRhTTZ4VHM

CrossFAB: Bridging the Gap between Personal Fabrication Research in HCI, Computer Graphics, Robotics, Art, Architecture, and Material Science. 2016

Since 2012, personal fabrication has emerged as a new topic in the HCI community with an increasing number of publications every year.

Konzentriert sich auf:

Computer graphics
Architecture & Robotics
Art
und Material Science

DIY and gender

The Crafting of DIY Fatherhood

Tawfiq Ammari, Sarita Schoenebeck, Silvia Lindtner
2017

This paper examines how the practice of DIY (do-it-yourself) making has become a productive frame for a collective of fathers in the U.S. to express masculinity, amidst increasingly precarious economics and shifting norms of gender and labor in the home.

Bowker and Star [10] argue that social and cultural categories emerge in relation to specific historical processes.

In this section, we first focus on how the social meaning of masculinity, domesticity, and DIY have evolved leading up to the present day.

Today, DIY making, Lindtner shows, is often construed by advocates of the maker movement as carrying the means to be a good parent by training children in the kind of self-reliance, hands-on, and solution-oriented intervention and innovation thinking considered so necessary to address contemporary educational, social, and economic challenges [36]. Broadly, DIY making is portrayed as a site of individual empowerment by democratizing participation in technology production; "everybody can be a maker," is a common phrase decorating the promotional banners of maker faires and the walls of hackerspaces. Despite the rhetoric of inclusivity, contemporary DIY making and hacking is often an exclusive practice, male-dominated and reserved for the affluent [54].

Sociomateriality

The lens of **sociomateriality, as developed in fields of STS and CSCW**, takes as its starting point the notion that social and material worlds are co-constituent, produced and enacted through one another [46]. Van House [58], for instance, drawing from Judith Butler's concept of performativity, explores how identities in the digital age are negotiated and enacted (i.e., performed) across a variety of sites, offline and online, and through both material and discursive means. Sociomateriality provides a potent theoretical lens to study how shifts in gender norms, economic, and social processes unfold in relation to one another by focusing on the ways in which through material production (including the producing of digital content like blogs), cultural meanings, social values, and norms are produced [6,14].

Maker Culture

Hackerspaces and the Internet of Things in China: How makers are reinventing industrial production, innovation, and the self

Silvia Lindtner
University of California, Irvine, USA and Fudan University, China
2014

The contemporary landscape of information technology is one that has been profoundly influenced by the emergence of the 'hacker culture' in the 1960s and 1970s.

Members of this hacker culture were committed to designing technologies which are open and modifiable by their users. Their approach towards technological 'makings' evolved out of an 'orientation toward the computer as a tool of empowerment and discovery'. 2

Chris Anderson, the former editor-in-chief of Wired magazine, suggests that this contemporary maker movement is driving forward the 'third industrial revolution' 4 – a generation of technology producers that expands from the earlier Internet and Web 2.0 techniques to make innovative hardware products and remake industrial production.

Making as individual empowerment
From the perspective of the makers with whom I worked, DIY making meant, among other things, **utilizing computational tools for creative expression and individual empowerment.** Many shared a commitment to the open and free sharing of software codes, hardware designs, ideas and resources, with the goal of reflecting on and reworking dominant social and economic frames.

Some people, for instance, are committed to starting up firms or grass-roots communities, others are eager to rethink contemporary meanings of technology production through re-use and open sharing while working for larger corporations, and yet others are driven to invent new organizational models or alternative approaches to the legal system. Based on their research on free and open source software, the anthropologists Gabriella Coleman and Alexander Golub describe this multitude of goals and motivations in open source communities as 'a mosaic of ethical positions'. 45

Many stressed that China lacked the necessary infrastructure
such as educational programmes for children and youths, funding programmes and independent organizations that support artists, entrepreneurs or generally anyone who works outside traditional frames and large institutions. They repeatedly emphasized that China's weaker position as compared to the rest of the world was not due to the low quality of its people and lack of wenming as government officials argue, but was caused by the lack of important infrastructures and support networks.

As politicians across regions are
calling upon all of us (technology producers, educators and researchers alike) to become creators of innovation, flexible and innovative workers, it is ever more important to understand how people craft positions in relation to this discourse and how they partially resist and exploit it. DIY makers exemplify this process, as they embed themselves in (and simultaneously challenge) political and market processes directed at involving all of us as potential producers of things, economies, and knowledge.

The sociomateriality of organisational life: considering technology in management research

Orlikowski, W. J. "The sociomateriality of organisational life: considering technology in management research." Cambridge
Journal of Economics 34 (2009): 125-141.

We are thus faced with the apparent contradiction that while technology is everywhere to be found in organizational life, it is largely absent from the recent management literature. To borrow an observation from Barad (2003), it seems that matter does not matter very much in most studies of organizational reality. A common explanation for this absence of materiality in the management literature is that technology is either invisible or irrelevant to researchers trained in social, political, economic, and institutional analyses of organizations. For these researchers, ontological priority is given to human actors and social structures, and as a result, technological artifacts (and materiality more generally) tend to disappear into the background and become taken for granted. With such a
perspective, it is not surprising that scholars do not work on questions about artifacts, and research done on this view thus underestimates the role and significance of technological artifacts.

Emergent Process
Challenging the notion that technology is an autonomous, external force, scholars adopting an emergent process perspective argued that technology results from the ongoing interaction of human choices, actions, social histories, and institutional contexts.

Scholars working from this perspective sought to explain how the particular interests and situated actions of multiple social groups shaped the designs, meanings, and uses of new technologies over time (Ciborra and Lanzara, 1994; Fulk, 1993; Heath and Luff, 2000; Prasad, 1993; Thomas, 1994; Zuboff, 1988).

These inquiries might examine how members' communication in MPK20 differs from their face-to-face interaction, how the roles, norms, and identities generated by members within MPK20 resemble or differ from those outside of MPK20. Other studies might examine the production of the MPK20 synthetic world, investigating the historical origins of such worlds, and the interpretations and actions of the designers and engineers who constructed MPK20 — what were their intentions, interests, and values in producing this synthetic world, how did they imagine the users and their activities within the world, what tools and techniques did they use to generate the code, how did their inscriptions in the MPK20 code depart from their espoused aspirations and assumptions, and so on.

Problems with Established Perspectives on Technology in Management Research
While the two perspectives of exogenous force and emergent process have generated valuable insights into the role of technology in organizations, they have also received their share of criticisms.

Research that views technology as an exogenous force has been criticized for ignoring or downplaying the role of history, social context, and human agency in shaping technology production, use, and change.

This exogenous force perspective has also been criticized for disregarding or reducing the dynamic and situated materialities that constitute technologies, and for tending to assume unproblematically that technology is largely exogenous, autonomous, homogeneous, predictable, and stable, and that it will operate as intended and designed across time and place (Orlikowski, 2007).

These assumptions are not borne out in practice, as Orlikowski and Iacono (2001, p. 131) note:

> Artifacts are usually made up of a multiplicity of often fragile and fragmentary components, whose interconnections are often partial and provisional and which require bridging, integration, and articulation in order for them to work together. We have a tendency to talk of [technological] artifacts as if they were of a piece—whole, uniform, and unified. For example, we talk about "the Technology," "the Internet," "the Digital Economy," as if these are single, seamless, stable, and the same, every time and everywhere. While such simplifications make it easy to talk about technologies, they also make it difficult to see that such technologies are rarely fully integrated, flawless, and unfailing, and that they can and often do break down, wear down, and shut down….
>
> Differences in system configurations, infrastructures, bandwidth, interfaces, accessibility, standards, training, business models, and citizens' rights and responsibilities guarantee that the experience of, say, "being on the Internet" in China will be different from that in Saudi Arabia or in the United States, let alone in various microcontexts of use.

Research that views **technology as an emergent process** has also been subject to critique. An emergent process perspective avoids reifying technology, but it also tends to downplay specific technological properties and affordances, focusing primarily on human interpretations and social actions. Given the ontological priority of this perspective, it is not surprising that the answers obtained by studies in this tradition privilege situated human agency.

The emergent process perspective has also been challenged on a number of additional points. For example, questions have been raised about some of the studies that assume that technological artifacts stabilize during design ("reach closure"). Critics have argued that such a presumption privileges the design stage and overlooks the ongoing and open-ended process of reinterpretation and reworking through which technological artefacts are modified and updated during use over time (Wajcman, 2000; Woolgar and Cooper, 1997).

In particular, there is a critical difference in the ontological priority given — on the one hand, to the technology and the often accompanying search for invariant technological impacts across time — and on the other hand, to the social and the often accompanying exploration of multiple, emergent and situated human-technology interactions over time. Despite these apparent differences, a closer examination indicates that the two perspectives share an underlying core presumption — that technology and humans are essentially different and separate realities. In this respect, both perspectives are based on an ontology of separateness, that is, "an ontology of separate things that need to be joined together" (Suchman, 2007, p. 257). These perspectives similarly share "a simple dualistic view of agency which claims that agency is located either in the human or in the artefact" (Introna, 2007, p. 3).

As Introna (2009, p. 26) writes:

> It would not be incorrect to say that our existence has now become so entangled with the things surrounding us (if it even makes sense to use the notion of 'surround') that it is no

> longer possible to say, in any definitive way, where we end and they begin, and vice versa. [...] We are the beings that we are through our entanglements with things – we are thoroughly hybrid beings, cyborgs through and through.

Such a relational ontology informs a number of perspectives that are beginning to influence research on technology in the management literature, and which may be characterized with the label
“entanglement in practice.”

Entanglement in Practice
One influential example of an **entanglement perspective is that of Actor Network Theory** (ANT), originally developed by sociologists Michel Callon (1986) and Bruno Latour (1987), and used by a number of organization scholars to **examine sociotechnical relations in the workplace** (Berg, 1997; Kaghan and Bowker, 2001; Monteiro and Hanseth, 1996; Scott and Wagner 2003; Walsham and Sahay, 1999). ANT proposes that entities have no inherent qualities, but acquire their form and attributes only through their relations with others in practice. From this perspective, there are no distinct and separate social or technological elements that might shape, or be shaped by, each other. Rather, technological artifacts should be treated symmetrically to the humans, and as equivalent
participants in a network of humans and non-humans that (temporarily) align to achieve particular effects. ANT entails a specific methodology for studying the “co-evolution of sociotechnical contexts and sociotechnical content” (Law and Callon, 1994, p. 21), whereby actors (human and non-human) assemble and associate the interests of others in a common project.

CHI 2018

The Making of Performativity in Designing [with] Smart Material Composites

- Bahareh Barati, Elisa Giaccardi, Elvin Karana

As the material becomes active in disclosing the fullness of its capabilities, the boundaries between human and nonhuman performances are destabilized in productive practices that take their departure from materials. This paper illuminates the embodied crafting of action possibilities in material-driven design (MDD) practices with electroluminescent materials. The paper describes and discusses aspects of the making process of electroluminescent materials in which matter, structure, form, and computation are manipulated to deliberately disrupt the affordance of the material, with the goal to explore unanticipated action possibilities and materialize the performative qualities of the sample. In light of this account, the paper concludes by urging the HCI community to performatively rupture the material, so to be able to act upon it as if it was always unfinished or underdeveloped. This, it is shown, can help open up the design space of smart material composites and reveal their latent affordances.

MABLE: Mediating Young Children's Smart Media Usage with Augmented Reality

- Gahgene Gweon, Bugeun Kim, Jinyoung Kim, Kung Jin Lee, Jungwook Rhim, Jueun Choi

There has been a growing concern over the huge increase in use of smart media by young children. This study explores the possibility of using augmented-reality(AR) for regulat-ing preschoolers' media usage behavior. With MABLE (mobile application for behavioral learning and education), parents can provide AR-assisted feedback by changing facial expressions and sound effects. When overlaying a smart media, which has MABLE running, in front of a QR marker on a puppet, a facial expression is displayed on top of the puppet's face. A two-week long experiment with 36 parent-child pairs showed that compared to using just the puppet, using MABLE showed higher amount of engage-ment among preschoolers. For the effectiveness of parental mediation in terms of self-control, our data showed mixed results. MABLE had positive effects in that the amount of rule-compliance increased and problematic behaviors de-creased, whereas the level of behavioral dependency on smart media was not influenced.

Grafter: Remixing 3D-Printed Machines

- Thijs Jan Roumen, Willi Müller, Patrick Baudisch

Creating new 3D printed objects by recombining models found in hobbyist repositories has been referred to as "re-mixing". In this paper, we explore how to best support users in remixing a specific class of 3D printed objects, namely those that perform mechanical functions. In our survey, we found that makers remix such machines by manually extracting parts from one parent model and combine it with parts from a different parent model. This approach often puts axles made by one maker into bearings made by another maker or combines a gear by one maker with a gear by a different maker. This approach is problem-atic, however, as parts from different makers tend to fit poorly, which results in long series of tweaks and test-prints until all parts finally work together. We address this with our interactive system grafter. Grafter does two things. First, grafter largely automates the process of extracting and recombining mechanical elements from 3D printed machines. Second, it enforces a more efficient approach to reuse: it prevents users from extracting indi-vidual parts, but instead affords extracting groups of me-chanical elements that already work together, such as axles and their bearings or pairs of gears. We call this mecha-nism-based remixing. In a final user study, all models that participants had remixed using grafter could be 3D printed without further tweaking and worked immediately.

PHUI-kit: Interface Layout and Fabrication on Curved 3D Printed Objects

- Michael D. Jones, Zann Anderson, Casey Walker, Kevin Seppi

We seek to make physical user interface (PHUI) design more like graphical user interface (GUI) design by using a drag-and drop interface to place widgets, allowing widgets to be repositioned and by hiding implementation details. PHUIs are interfaces built from tangible widgets arranged on the surfaces of physical objects. PHUI layout will become more important as we move from rectangular screens to purpose-built interactive devices. Approaches to PHUI layout based on sculpture make it difficult to reposition widgets, and software approaches do not involve placing widgets on the device exterior. We created PHUI-kit, a software approach to PHUI layout on 3D printed enclosures, which has a drag-and-drop interface, supports repositioning of widgets, and hides implementation details. We describe algorithms for placing widgets on curved surfaces, modifying the enclosure geometry, and routing wiring inside the enclosure. The tool is easy to use and supports a wide range of design possibilities.

MatchSticks: Woodworking through Improvisational Digital Fabrication

- Rundong Tian, Sarah Sterman, Ethan Chiou, Jeremy Warner, Eric Paulos

Digital fabrication tools have broadened participation in making and enabled new methods of rapid physical prototyping across diverse materials. We present a novel smart tool designed to complement one of the first materials employed by humans - wood - and celebrate the fabrication practice of joinery. Our tool, MatchSticks, is a digital fabrication system tailored for joinery. Combining a portable CNC machine, touchscreen user interface, and parametric joint library, MatchSticks enables makers of varying skill to rapidly explore and create artifacts from wood. Our system embodies tacit woodworking knowledge and distills the distributed workflow of CNC tools into a hand tool; it operates on materials existing machines find difficult, produces assemblies much larger than its workspace, and supports the parallel creation of geometries. We describe the workflow and technical details of our system, present example artifacts produced by our tool, and report results from our user study.

Medley: A Library of Embeddables to Explore Rich Material Properties for 3D Printed Objects

- Xiang 'Anthony' Chen, Stelian Coros, Scott E. Hudson

In our everyday life, we interact with and benefit from objects with a wide range of material properties. In contrast, personal fabrication machines (e.g., desktop 3D printers) currently only support a much smaller set of materials. Our goal is to close the gap between current limitations and the future of multi-material printing by enabling people to explore the reuse of material from everyday objects into their custom designs. To achieve this, we develop a library of embeddables--everyday objects that can be cut, worked and embedded into 3D printable designs. We describe a design space that characterizes the geometric and material properties of embeddables. We then develop Medley---a design tool whereby users can import a 3D model, search for embeddables with desired material properties, and interactively edit and integrate their geometry to fit into the original design. Medley also supports the final fabrication and embedding process, including instructions for carving or cutting the objects, and generating optimal paths for inserting embeddables. To validate the expressiveness of our library, we showcase numerous examples augmented by embeddables that go beyond the objects' original printed materials.

Challenges and Opportunities for Technology-Supported Activity Reporting in the Workplace

- Di Lu, Jennifer Marlow, Rafal Kocielnik, Daniel Avrahami

Effective communication of activities and progress in the workplace is crucial for the success of many modern organizations. In this paper, we extend current research on workplace communication and uncover opportunities for technology to support effective work activity reporting. We report on three studies: With a survey of 68 knowledge workers followed by 14 in-depth interviews, we investigated the perceived benefits of different types of progress reports and an array of challenges at three stages: Collection, Composition, and Delivery. We show an important interplay between written and face-to-face reporting, and highlight the importance of tailoring a report to its audience. We then present results from an analysis of 722 reports composed by 361 U.S.-based knowledge workers, looking at the influence of the audience on a report's language. We conclude by discussing opportunities for future technologies to assist both employees and managers in collecting, interpreting, and reporting progress in the workplace.

Off-Line Sensing: Memorizing Interactions in Passive 3D-Printed Objects

- Martin Schmitz, Martin Herbers, Niloofar Dezfuli, Sebastian Günther, Max Mühlhäuser

Embedding sensors into objects allow them to recognize various interactions. However, sensing usually requires active electronics that are often costly, need time to be assembled, and constantly draw power. Thus, we propose off-line sensing: passive 3D-printed sensors that detect one-time interactions, such as accelerating or flipping, but neither require active electronics nor power at the time of the interaction. They memorize a pre-defined interaction via an embedded structure filled with a conductive medium (e.g., a liquid). Whether a sensor was exposed to the interaction can be read-out via a capacitive touchscreen. Sensors are printed in a single pass on a consumer-level 3D printer. Through a series of experiments, we show the feasibility of off-line sensing.

SymbiosisSketch: Combining 2D & 3D Sketching for Designing Detailed 3D Objects in Situ

- Rahul Arora, Rubaiat Habib Kazi, Tovi Grossman, George Fitzmaurice, Karan Singh

We present SymbiosisSketch, a hybrid sketching system that combines drawing in air (3D) and on a drawing surface (2D) to create detailed 3D designs of arbitrary scale in an augmented reality (AR) setting. SymbiosisSketch leverages the complementary affordances of 3D (immersive, unconstrained, life-sized) and 2D (precise, constrained, ergonomic) interactions for in situ 3D conceptual design. A defining aspect of our system is the ongoing creation of surfaces from unorganized collections of 3D curves. These surfaces serve a dual purpose: as 3D canvases to map strokes drawn on a 2D tablet, and as shape proxies to occlude the physical environment and hidden curves in a 3D sketch. SymbiosisSketch users draw interchangeably on a 2D tablet or in 3D within an ergonomically comfortable canonical volume, mapped to arbitrary scale in AR. Our evaluation study shows this hybrid technique to be easy to use in situ and effective in transcending the creative potential of either traditional sketching or drawing in air.

Silicone Devices: A Scalable DIY Approach for Fabricating Self-Contained Multi-Layered Soft Circuits using Microfluidics

- Steven Nagels, Raf Ramakers, Kris Luyten, Wim Deferme

We present a scalable Do-It-Yourself (DIY) fabrication workflow for prototyping highly stretchable yet robust devices using a CO_2 laser cutter, which we call Silicone Devices. Silicone Devices are self-contained and thus embed components for input, output, processing, and power. Our approach scales to arbitrary complex devices as it supports techniques to make multi-layered stretchable circuits and buried VIAs. Additionally, high-frequency signals are supported as our circuits consist of liquid metal and are therefore highly conductive and durable. To enable makers and interaction designers to prototype a wide variety of Silicone Devices, we also contribute a stretchable sensor toolkit, consisting of touch, proximity, sliding, pressure, and strain sensors. We demonstrate the versatility and novel opportunities of our technique by prototyping various samples and exploring their use cases. Strain tests report on the reliability of our circuits and preliminary user feedback reports on the user-experience of our workflow by non-engineers.

Accessible Maps for the Blind: Comparing 3D Printed Models with Tactile Graphics

- Leona Holloway, Kim Marriott, Matthew Butler

Tactile maps are widely used in Orientation and Mobility (O&M) training for people with blindness and severe vision impairment. Commodity 3D printers now offer an alternative way to present accessible graphics, however it is unclear if 3D models offer advantages over tactile equivalents for 2D graphics such as maps. In a controlled study with 16 touch readers, we found that 3D models were preferred, enabled the use of more easily understood icons, facilitated better short term recall and allowed relative height of map elements to be more easily understood. Analysis of hand movements revealed the use of novel strategies for systematic scanning of the 3D model and gaining an overview of the map. Finally, we explored how 3D printed maps can be augmented with interactive audio labels, replacing less practical braille labels. Our findings suggest that 3D printed maps do indeed offer advantages for O&M training.

ColorMod: Recoloring 3D Printed Objects using Photochromic Inks

- Parinya Punpongsanon, Xin Wen, David S. Kim, Stefanie Mueller

Recent research has shown how to change the color of existing objects using photochromic materials. These materials can switch their appearance from transparent to colored when exposed to light of a certain wavelength. The color remains even when the object is removed from the light source. The process is fully reversible allowing users to recolor the object as many times as they want. So far, these systems have been limited to single color changes, i.e. changes from transparent to colored. In this paper, we present ColorMod, a method to extend this approach to multi-color changes (e.g., red-to-yellow). We accomplish this using a multi-color pattern with one color per voxel across the surface of the object. When recoloring the object, our system locally activates only those voxels that have the desired color and turns all other voxels off. We describe ColorMod's hardware/software system and its user interface that comes with a conversion tool for 3D printing as well as a painting tool that matches physical voxels with the desired appearance. We also contribute our own material formula for a 3D-printable photochromic ink.

Thermorph: Democratizing 4D Printing of Self-Folding Materials and Interfaces

- Byoungkwon An, Ye Tao, Jianzhe Gu, Tingyu Cheng, Xiang 'Anthony' Chen, Xiaoxiao Zhang, Wei Zhao, Youngwook Do, Shigeo Takahashi, Hsiang-Yun Wu, Teng Zhang, Lining Yao

We develop a novel method printing complex self-folding geometries. We demonstrated that with a desktop fused deposition modeling (FDM) 3D printer, off-the-shelf printing filaments and a design editor, we can print flat thermoplastic composites and trigger them to self-fold into 3D with arbitrary bending angles. This is a suitable technique, called Thermorph, to prototype hollow and foldable 3D shapes without losing key features. We describe a new curved folding origami design algorithm, compiling given arbitrary 3D models to 2D unfolded models in G-Code for FDM printers. To demonstrate the Thermorph platform, we designed and printed complex self-folding geometries (up to 70 faces), including 15 self-curved geometric primitives and 4 self-curved applications, such as chairs, the simplified Stanford Bunny and flowers. Compared to the standard 3D printing, our method saves up to 60% - 87% of the printing time for all shapes chosen.

Greater than the Sum of its PARTs: Expressing and Reusing Design Intent in 3D Models

- Megan Hofmann, Gabriella Hann, Scott E. Hudson, Jennifer Mankoff

With the increasing popularity of consumer-grade 3D printing, many people are creating, and even more using, objects shared on sites such as Thingiverse. However, our formative study of 962 Thingiverse models shows a lack of re-use of models, perhaps due to the advanced skills needed for 3D modeling. An end user program perspective on 3D modeling is needed. Our framework (PARTs) empowers amateur modelers to graphically specify design intent through geometry. PARTs includes a GUI, scripting API and exemplar library of assertions which test design expectations and integrators which act on intent to create geometry. PARTs lets modelers integrate advanced, model specific functionality into designs, so that they can be re-used and extended, without programming. In two workshops, we show that PARTs helps to create 3D printable models, and modify existing models more easily than with a standard tool.

[Mechanism Perfboard: An Augmented Reality Environment for Linkage Mechanism Design and Fabrication]

- Yunwoo Jeong, Han-Jong Kim, Tek-Jin Nam

Prototyping devices with kinetic mechanisms, such as automata and robots, has become common in physical computing projects. However, mechanism design in the early-concept exploration phase is challenging, due to the dynamic and unpredictable characteristics of mechanisms. We present Mechanism Perfboard, an augmented reality environment that supports linkage mechanism design and fabrication. It supports the concretization of ideas by generating the initial desired linkage mechanism from a real world movement. The projection of simulated movement within the environment enables iterative tests and modifications in real scale. Augmented information and accompanying tangible parts help users to fabricate mechanisms. Through a user study with 10 participants, we found that Mechanism Perfboard helped the participant to achieve their desired movement. The augmented environment enabled intuitive modification and fabrication with an understanding of mechanical movement. Based on the tool development and the user study, we discuss implications for mechanism prototyping with augmented reality and computational support.

[PEP (3D Printed Electronic Papercrafts): An Integrated Approach for 3D Sculpting Paper-Based Electronic Devices]

- Hyunjoo Oh, Tung D. Ta, Ryo Suzuki, Mark D. Gross, Yoshihiro Kawahara, Lining Yao

We present PEP (Printed Electronic Papercrafts), a set of design and fabrication techniques to integrate electronic based interactivities into printed papercrafts via 3D sculpting. We explore the design space of PEP, integrating four functions into 3D paper products: actuation, sensing, display, and communication, leveraging the expressive and technical opportunities enabled by paper-like functional layers with a stack of paper. We outline a seven-step workflow, introduce a design tool we developed as an add-on to an existing CAD environment, and demonstrate example applications that combine the electronic enabled functionality, the capability of 3D sculpting, and the unique creative affordances by the materiality of paper.

[Antibiotic-Responsive Bioart: Exploring DIYbio as a Design Studio Practice]

- Stacey Kuznetsov, Cassandra Barrett, Piyum Fernando, Kat Fowler

Our work links hybrid practices from biology, fine arts, and design in a studio setting to support materially-oriented engagement with biotechnology. Using autoethnographic methods, we present our two-year process of converting an HCI studio into a BSL-1 (biosafety level 1) facility, our iterative development of low-cost tools, and our own self-reflexive experimentation with (DIY)bio protocols. Insights from this work led us to design a weeklong bioart course, whereby junior highschool students creatively "painted" with bacteria and antibiotic substances, digitally designed stencils from the resulting petri dish images, and screenprinted them onto physical artifacts. Our findings reveal the nuances of working with biological, analog, and digital materials in a design studio setting. We conclude by reflecting on DIYbio studio as a gathering of diverse actors who work with hybrid materials to give physical form to matters of concern.

[CraftML: 3D Modeling is Web Programming]

- Tom Yeh, Jeeeun Kim

We explore web programming as a new paradigm for programmatic 3D modeling. Most existing approaches subscribe to the imperative programming paradigm. While useful, there exists a gulf of evaluation between procedural steps and the intended structure. We present CraftML, a language providing a declarative syntax where the code is the structure. CraftML offers a rich set of programming features familiar to web developers of all skill levels, such as tags, hyperlinks, document object model, cascade style sheet, JQuery, string interpolation, template engine, data injection, and scalable vector graphics. We develop an online IDE to support CraftML development, with features such as live preview, search, module import, and parameterization. Using examples and case studies, we demonstrate that CraftML offers a low floor for beginners to make simple designs, a high ceiling for experts to build complex computational models, and wide walls to support many application domains such as education, data physicalization, tactile graphics, assistive devices, and mechanical components.

[RoMA: Interactive Fabrication with Augmented Reality and a Robotic 3D Printer]

- Huaishu Peng, Jimmy Briggs, Cheng-Yao Wang, Kevin Guo, Joseph Kider, Stefanie Mueller, Patrick Baudisch, François Guimbretière

We present the Robotic Modeling Assistant (RoMA), an interactive fabrication system providing a fast, precise, hands-on and in-situ modeling experience. As a designer creates a new model using RoMA AR CAD editor, features are constructed concurrently by a 3D printing robotic arm sharing the same design volume. The partially printed physical model then serves as a tangible reference for the designer as she adds new elements to her design. RoMA's proxemics-inspired handshake mechanism between the designer and the 3D printing robotic arm allows the designer to quickly interrupt printing to access a printed area or to indicate that the robot can take full control of the model to finish printing. RoMA lets users integrate real-world constraints into a design rapidly, allowing them to create well-proportioned tangible artifacts or to extend existing objects. We conclude by presenting the strengths and limitations of our current design.