Makers in the Plant? Exploring the Impact of Knowledge IT Artifacts on DIY Practices in Manufacturing Firms

Luca Cremona and Aurelio Ravarini
School of Industrial Engineering, Università Carlo Cattaneo – LIUC,
C.so Matteotti 22, Castellanza (VA), Italy

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Abstract: In this study we investigate the impact of digital technologies on fabrication activities carried out by a worker leading her organizational role to be critically reshaped. We assume that the characteristics of the Makers (individual and environmental characteristics) could be applied to workers in a manufacturing plant, bringing benefits in terms of higher achievements deriving by the digitization of fabrication. We propose to interpret the digital technologies enabling digitization through the lens of the KITA construct. Two case studies have been carried out in order to explore these assumptions and providing preliminary insights of the effects of Digital DIY practices on manufacturing firms.

1 INTRODUCTION: MAKERS AND DIGITAL FABRICATION

Makers are an emerging community of self-described DIY-enthusiasts, tinkerers and hobbyists. Popularized by the quarterly magazine MAKE and annual Maker Faire events, the term *maker* and its meaning seem to have originated in the context of the maker movement and the do-it-yourself world (Anderson 2012, Lande 2013, Hatch 2013). McFedries (2007) calls the maker: “high-tech tinkerer who lives to take things apart, modify... them to perform some useful or interesting task, and then (sometimes) put them back together.” In the context of the maker movement Honey and Siegel (2010) used the terms circuit bender, personal fabrication, and risk takers.

Noteworthy, a number of articles (McFedries 2007, Kafai 2011, Dougherty 2012, Campbell 2012, Schön 2014, Hallaq 2014, Frissen 2015) mention makers referring to an educational context. Dale Dougherty (2012), founder of MAKE Magazine and Maker Faire festivals, describes making as “learning by doing”, pointing out the development of new skills as a core aspect.

The diffusion of individuals with such characteristics, led Anderson (2012) to envision an industrial revolution in “making”, a disruptive change that should have radically transformed the manufacturing industry. He forecasted that the spread of technologies such as 3D printers could enable Makers to fully exploit their creative potential and challenge the current structure of manufacturers and their supply chains (Anderson 2012).

While "Makers" are evolving into a phenomenon with growing economical relevance, another revolution is affecting the creation of physical products: digitization of the manufacturing. According to a recent survey four disruptions are occurring in manufacturing: rise in data volumes, emergence of analytics and business-intelligence capabilities; new forms of human-machine interaction; and improvements in transferring digital instructions to the physical world (McKinsey Quarterly 2015). Rapid prototyping technologies are impacting business processes because the offer this knowledge to the people (Oxman 2007). Specifically, they impact the work of traditional craftsmanship involving the knowledge and skill-set of particular practical arts. By bringing new methods and technologies for production (e.g. digital desktop fabrication), knowledge work, craft, and design are recombined in novel ways (Ratto and Ree 2012).

While the two phenomena belong to different domains: Makers are single individuals, digitization of manufacturing appears in production plants, it is possible to recognize that they share common or at least overlapping roots. In both cases:

- the activity subject of the change is the process of fabrication (the transformation of physical objects),

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- digital technologies are a necessary condition to enable the change,
- the change is highly human centric: it occurs thanks to individuals who own - or develop – soft skills, besides the technical ones.

1.1 Digital DIY and Knowledge IT Artifacts

In a recent position paper, NN et al. (2016) argue that these two phenomena - in fact - can be described by introducing a more general framework, named Digital DIY (DiDIY). Under this framework, a “DiDIY activity” is carried out when the following conditions occur altogether: a) a DiDIYer, i.e. a certain organizational role, b) carries out on her own certain activities, activities previously carried out by experts (this aspect deals with the traditional notion of Do-It-Yourself), c) by exploiting certain digital technologies, d) possibly exploiting the knowledge about the activity shared within a certain community of individuals (this aspect deals with the innovative notion of Do-It-Together, where “together” refers to a community the DiDIYer belongs to).

The context of a DiDIY activity can be interpreted at the light of the Knowledge IT Artifact (KITA) construct. According to Cabitza and Locoro (2014) definition of the “situated perspective” a knowledge artifact (KA) do not necessarily represent knowledge per se but rather promote knowledge-related processes like innovation, decision making and learning: in this latter case the nature of the KA cannot be decoupled, nor generalized, from the specific setting or Community of Practice, or from the boundary between communities where the KA is supposed to play its role of knowledge facilitator and transfer medium (Cabitza and Locoro, 2014).

Following this rationale, any digital technology in the context of a DiDIY activity, as defined above, can be seen as a KA.

In this study, we investigate the impact of digital technologies on fabrication activities carried out by a worker leading her organizational role to be critically reshaped. We assume that the characteristics of the Makers (individual and environmental characteristics) could be applied to workers in a manufacturing plant, bringing benefits in terms of higher achievements deriving by the digitization of fabrication. We propose to interpret the digital technologies enabling digitization through the lens of the KITA construct.

For example, a worker operating with the mindset and skills typical of a maker could exploit digitization not merely eliminating routinely tasks, but - thanks to a digital technology, a KA - getting a better understanding of the fabrication process, and thus becoming able to design and experiment improvements.

2 THEORETICAL BACKGROUND: INDIVIDUAL AND ENVIRONMENTAL CHARACTERISTICS OF MAKING

The literature about the Maker Movement allows us to draw a general picture of the characteristics qualifying the makers and the environment in which they operate. At the individual level, makers typically participate in a community, driven mainly by values (Dewey, 1929), beliefs (Elby et al., 2001), and dispositions (Perkins et al., 2000). These drivers help in shaping the Maker mindset: playful, asset- and growth-oriented, failure positive, and collaborative (Martin, 2015; Peppler, 2013).

Dougherty (2013) pointed out that it is “experimental play” that have fostered the rise of new digital tools, an easier access to components and growth of online communities eventually culminated with the explosion of the Maker Movement (Martin, 2015). Playful activities along with fun are at the hearth of Makers’ activities that group and work together for “their pleasure in making and using their own inventions’’ (Gershenfeld, 2005). Persistence in the challenge of making (Vansteenkiste et al., 2004) encourage experimentation and create the basic conditions for the development of conceptual knowledge and adaptive expertise (Hatano et al., 1986). Another important element emerging from seminal papers is the freeness of Makers to focus on doing the task or job they want. They can strengthen their expertise background as long as focusing on something new to learn. Within the Maker Movement the crucial topic is that, they focus on skills rather than abilities. As reported by Martin (2015), “making advocates a growth mindset, where, given effort and resources, anyone can learn the skills needed to complete any project they can imagine”.

Within the Makers community it is recognizable a free-choice nature of making, that emphasizes assets and the ability to learn over deficits—an orientation sometimes missing in school settings (Gutierrez et al., 2003). Therefore, Makers do not experience failures of making as demoralizing (Soep, 2014) but they understand that overcoming small obstacles is equally important. Petrich et al. (2013) state that “the process of becoming stuck and then unstuck is the heart of tinkering”, and they find that such moments are often among the most salient in participants’ post-activity interviews. Sharing ideas, project, helping others, making and connecting characterize Makers under the collaboration perspective. This mindset is probably the most important element when talking about Makers and is shown both in online and in offline communities where Makers group and collaborate to show their work (Kuznetsov et al., 2010).

Besides this personal traits, the Makers movement has been enabled by the presence of favorable environmental conditions: a playful learning environment (Vansteenkiste et al., 2004), learning environments that advocate a growth mindset, encouraging persistence, challenge seeking, and learning (Dweck, 2000). Learning environments that support youth autonomy and control of their endeavors are “more motivating, support engagement and persistence, identity development, and the growth of resourcefulness” (Azevedo, 2011; Ryan et al., 2000).

3 RESEARCH METHOD

This section aims at introducing the methodology used for investigating the theoretical constructs within organizational settings. After introducing the chosen methodology and motivating the need of an exploratory study, the data collection process is introduced and described. Finally, data analysis is presented.

3.1 Methodology

In the empirical section of this research we used an exploratory case study, whose aim is to enable the emergence of the impact of digital technology on work practices and people competence profiles. Two criteria guided the choice of a case study research: the cost per subject and the potential for theory generation. A multiple-case study approach (Yin, 2003) was chosen to investigate the theoretical framework presented above using constructs to order the data and relate to earlier literature. Multiple cases strengthen the results by replicating the patterns. and thus providing external validation to the findings. Each case served to confirm or disconfirm the conclusions drawn from the others.

The unit of analysis chosen was “a worker in a manufacturing firm”. This unit was analyzed through the collection of primary (interviews, direct observation, and informal discussions), and secondary data (firms documents and web pages from the firm web site). Before starting the collection of primary data (Darke et al., 1998), some preliminary background information was collected in order to help the interviewer during the data collection process. The preliminary information came from the Internet web site of the firm and some supplementary information was given by the organizational interviewee. Together with a representative of each firm, the names and the positions of all the potential participants were identified and contacted for an interview (Darke et al., 1998). Following Yin (2003), a case-study protocol was designed including the following sections: overview of the project (objectives and issues), field procedures, questions, and guidance for the report.

The interviews were semi-structured interviews (Kerlinger, 1964; Emory, 1980). In order to operationalize the theoretical constructs and ground the findings, whenever possible, key representatives of a “worker” were interviewed. The interviews were focused on introducing the main themes and sub-themes to discuss together with the interviewee. At the beginning of each interview an introduction on the reasons and the objects of the interview was performed (Miles et al., 1994). This explanation aimed at reducing the researcher effects at the site, which could bias the data collection (Darke et al., 1998; Miles et al., 1994). The interview guide was designed to gather the characteristics of the interviewee and what is her view. The set of data produced by each interview was analyzed in parallel with the prosecution of the other interviews in order to use the content of the previous interviews as source of questions to ask in the next interviews (Miles & Huberman, 1994). To increase homogeneity and comparability between the firms, a selection was made according to specific criteria such as B2B or B2C situation and similarity of firm size. Cases were chosen for enabling theoretical and literal replications (Yin, 2003).

3.2 Data Collection

A questionnaire has been implemented as a guideline to perform the interviews. The questionnaire is composed of 4 sections, one in respect of each focal topic found in literature, and 25 questions. Since the research was highly exploratory, a pilot-case was followed by a multiple case study involving other firms selected appropriately according to the phenomenon object of the study (Yin, 2003; Dubé and Paré, 2003). To build a triangulation and to give rigor to the study other sources of evidence will be included: direct observations, historical archive records, physical artefacts. The quantitative data are collected directly on a copy of the interview guide by the interviewer, while the qualitative data produced by the interview are synthesized in a report, immediately after each interview. These reports, the quantitative data collected on the direct observation and the collected secondary data were archived in a repository. The questionnaire, as previously mentioned, is divided into four main sections plus introduction. One round of interviews has been carried out in order to interview the 2 representatives for each firm.

3.3 Data Analysis

All interviews have been tape-recorded and then transcribed. Durations of the interviews were between one hour and one hour and a half, producing an audio material of 150 minutes in total. In addition to the interviews, secondary data, such as website pages and documentations, have been collected. The data were encoded and structured into "projects" using the software NVivo 10 following a grounded theory approach (Strauss 1987, Glaser 1992) that aims at finding properties or links between data. The coding procedure was done as follows: first, in order to mitigate potential bias, a master student (first coder) who had not taken part in the interviews read and coded the interview transcripts by identifying text passages that included information about the constructs emerged from the literature. Following the coding of the first coder, another master student (second coder), likewise, coded the transcripts. The comparison of the two coding resulted above inter-coder reliability threshold defined by Holsti (1969). The two coders then examined the mismatched coding and agreed on a final coding matrix that was used for the data analysis. The reasons for mismatches were always very obvious (e.g. one coder had simply overseen an issue within a statement). On top of this approach an Assistant Professor (third coder) acted as referee providing guidance whenever needed. Eventually, a second Assistant Professor contributed in guaranteeing the coherence with the DiDIY context. For the purpose of literal and theoretical replication, the instances of the theoretical constructs were determined for each firm whenever possible. A purposeful sampling strategy was pursued in order to stay in line with the research objectives and the multiple case studies design (Quinn Patton, 2002).

3.4 The Context of the Empirical Study

The context of the empirical study was represented by two manufacturing firms that recently carried out a digital transformation of their internal core processes. The digitalization of the physical assets reshaped how workers interact with the production environment and impacted on their competences.

Table 1. Overview of the firms involved in the empirical study.

	FIRM 1	FIRM 2
industry	Mechanical	Textile
employees	140	91
turnover (2015)	60-70 Mln. €	14 Mln. €

4 ANALYSIS OF COLLECTED DATA

This section discusses the main topics emerging from the interviews with regard to the framework previously presented. In this light, there is an attempt to discuss how the work of a workmen is reshaped according to the influence of DiDIY. Plus, by understanding what kind of activities can be DiDIY-related, there is an attempt to analyze how the work of a workman is changing with the evolution of other organizational roles in the firms' object of the study.

4.1 Within-case Analysis

The first firm is operating in the mechanical industry, that produces professional and industrial coffee machines, used in a large number of bars, restaurants and hotels. The firm offers to customers a series of technologically advanced products that makes it one of the most appreciated organization in its market.

As a result of data analysis three important digital innovations introduced, or currently in the process of being introduced, come out as relevant:

1. *Implementation of electronic documents*: These ones are used by company's sales men that can access in real-time information, even from their mobile device, about machines being in production
2. *Automatic warehouse:* Thanks to this new innovation, workers do not need to look for the items needed anymore. A computer checks inventory in real-time, a robot picks up the item from the shelf and put it at the disposal of workers who only need to take it and deliver it to the specific area

3. *Automatic trial:* The company is thinking to introduce a new system that allows to automate some operations before were carried out manually by the worker during the trial process of the machines

According to the DiDIY framework previously introduced, the use of electronic documents allows to sales men (DiDIY-ers) a real-time access to the information needed. In this way sales men did not need any more to ask to production manager what machines are ready or not to answer to customers' needs but they can do it by themselves using their own personal devices. Due to that new technology they not only change how they worked before but they also acquire a new level of autonomy because they do not depend any more from production manager but they can develop activities without any experts' support. This one can be considered as a "DiDIY activity" because three point of the framework are respected.

The second digital innovation is different from the previous one. Here the firm decided to introduce a new system to automate warehouse management. While before workers were in charge of deciding what items to pick up following a list of scheduled objects, now it is the system, guided by the ERP system, that communicates what items are needed and where (i.e. which inventory position) they are. This new solution is facilitating and easing all workers' activities by increasing the speed of the process and its efficiency; on the contrary, it reduces the autonomy of the workers because they are now guided by the systems therefore losing the minimum decisional power they had before. Also here we have a new digital innovation that changes the way of people work but, differently than before, this change is only a way to automate a process, to improve it, but it did not cause relevant impacts on workers. For that reason, it is not possible to consider this innovation as a "DiDIY activity".

The last digital innovation is about the trial process of the machines. While before workers needed to work on one machine a time only now, thanks to the new automatic systems, they can work on more than a single one because the program does the work automatically. Therefore, even here is possible to observe that, thanks to the new technology, workers' autonomy increases but in a different way with respect to the first case. Here, the worker gains freedom from the process and becomes a little bit less worker and a little more manager, such as a supervisor of the whole process. The new solution increases the speed of the process, because it is now possible to work in parallel on more machines, but it also changes significantly the way employees work, increasing their autonomy and their decisional power. For that reason, also this last innovation analyzed can be considered as a "DiDIY activity".

With regard to the framework before introduced, we can say that both the digital innovations explained present a set of "DiDIY activities" that described in the last points of the framework. As emerging from the interview they consider really import to analyze and study innovations with their workers. In fact, most of the time innovations are implemented responding to specific needs coming from workers, asking for new and smarter way to develop their activities. The firm gives a really big importance to common moment of sharing too, where all employees can share their opinions. They can happen both within formal meetings and informal contexts such as during the coffee break where people can share knowledge and expertise. What clearly emerges is that for the firm "Do-It-Together" is not only an idea, but more a real culture.

The second firm is a commission printer of cotton fibers with rotary and flat machines. Their mission is to be a vibrant competitor offering the highest standards of quality at low cost and be proud in using the most recent production technologies, management control systems and material handling techniques. Conveyer belts and custom robotics simplify and accelerate color-tank operations, while a fully automated warehouse allows efficient storage of clients' fabrics during the various steps of manufacturing. The key process carried out are related to the textile printing activities; the print process can be defined through the following steps:

- Receipt of the printing order by customer
- Preparation of printing dispositions and dispatch to the worker
- Preparation of the machines and start of textile printing
- Print's checks

After printing activities, there will be fixing, washing and packaging activities. The technological innovation is supported by a software that manages the production progress. At the first stage, the software generates paper dispositions composed by few basic information, displayed thought monitors to the workers. Originally the software was merely based on a simple copy of non editable and sometimes incomplete information and records. Up today, the software has been integrated with all the required information allowing and giving to the workers a fully access to the information and a faster process of training. This digital innovation, has been customized for the firm, with the aim to industrialize the product ensuring more efficient activities. First of all, the new software enables workers to get complete and updated information in real-time, and always available on the printing machines making them accessible to all stakeholders. In case of lack of data this solution is not possible anymore, it needs a definition of all dispositions in order to avoid any communications between worker and department head. Nowadays, the changes of printing dispositions can be handled by workers who interacts with production progress software, even providing data updating in real-time. All activities of productions are recorded during the process, so in case of a sudden interruption of printing machines, workers of the following shift can have a complete view of the situation and manage possible problems, avoiding calls to colleagues or department heads and the usage of post-it attached to machines as a way to share anomalies. A big shift driven by the technology is that projects and printing dispositions are already saved by production progress software and, consequentially, set-up time of the machine and number of errors made during printing of fabrics are drastically reduced to ensure an equal level of quality. The production progress software allows an integrated data management and information is available from the beginning until the end of production process. Due to the absence of flexibility in the processes, the autonomy of workers is not granted, but a great advantage is the speeding up of information retrieval. Furthermore, another advantage is the use of the saved time to improve the quality of the production process.

With regard to how the digital innovation of the firm is contextualized within the DiDIY framework, we can recall DiDIY Activities concept and define it within the current case: a DiDIY-er, is the printing department head, who thanks to a software that manages the production progress, changes the way in which he coordinates activities. Up today, he gives orders and checks prints without asking the support of the person that creates the sequence of production activities on textiles and, therefore, can reduce the number of support requests to the printing director and to customers. The opportunity to have all necessary information in real time allows to a faster elaboration of data and a more efficient decision making process that can communicated to the machine operators.

With regards to the knowledge sharing we reported an absence of formal processes that manage it. It casually occurs with workers in the same shift only or with department heads. Both for a matter of security and endogenous reason of the firm process – quite vertical and not flat – the knowledge shared with other communities is totally absent (i.e. the workers cannot access to internet). Not all the four points of the framework are respected so this activity can be considered only as a DiDIY activity.

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REFERENCES

Anderson, C.: Makers: The new industrial revolution. New York, NY: Random House (2012).
Azevedo, F. S.: Lines of practice: A practice-centered theory of interest relationships. Cognition and Instruction, 29, 2, pp. 147–184 (2011).
Bedeian, A. G., Wren, D. A.: Most Influential Management Books of the 20th Century. Organizational Dynamics, 29, 3, pp. 221–225 (2001).
Benbasat, I., Goldstein, D. K., Mead, M.: The Case Research Strategy in Studies of Information Systems. MIS Quarterly, 11, 3, pp. 369-386 (1987).
Bernstein, A., Raman, A.: The Great Decoupling: An Interview with Erik Brynjolfsson and Andrew McAfee. Harvard Business Review. http://bit.ly/2acgQbh (2015).
Buxmann, P., Hinz O.: Makers. Business & Information Systems Engineering, 5, 5, pp. 357-360 (2013).
Cabitza, F., & Locoro, A. “Made with Knowledge”: Disentangling the IT Knowledge Artifact by a Qualitative Literature review”, KMIS 2014, Rome, Oct. 2014
D’Aveni, R.: 3D printing will change the world. HBR, 91, 3, pp.34 (2013).
D’Aveni, R.: The 3-D Printing Revolution. https://hbr.org/2015/05/the-3-d-printingrevolution (2015).
Darke, P., Shanks, G., Broadbent, M.: Successfully Completing Case Study Research: Combining Rigour, Relevance and Pragmatism. ISJ, 8, pp. 273-289 (1998).
Davenport, T. H., Kirby, J.: Beyond Automation. http://bit.ly/2a4l5U3 (2015).
Dewey, J.: The quest for certainty: A study of the relation of knowledge and action, New York, NY: Minton, Balch and Company (1929).
Dougherty, D.: The maker mindset. In M. Honey & D.E. Kanter (Eds.), Design, make, play: Growing the next generation of STEM innovators, pp. 7-11. New York, NY: Routledge (2013).
Dubé, L., Paré, G.,: Rigor in Information Systems Positivist Case Research: Current Practices, Trends, and Recommendations. MIS Quarterly, 27, 4, pp. 597-636 (2003).

Dweck, C.: Self-theories: Their role in motivation, personality, and development. Psychology Press (2000).

Edwards, C.: Home is where the art is': Women, handicrafts and home improvements 1750 – 1900. Journal of design history, 19(1): 11–21 (2006).

Elby, A., Hammer, D.: On the substance of a sophisticated epistemology. Science Education, 85, 5, pp. 554–567 (2001).

Emory, W. C.: Business Research Methods. Irwin (1980).

Franke N., Von Hippel E., Schreier M.: Finding Commercially Attractive User Innovations: A Test of Lead-User Theory. Journal of Product Innovation Management, vol.3, Issue 4, pages 301–315 (2006).

Gershenfeld, N.: Fab: The coming revolution on your desktop — from personal computers to personal fabrication. Cambridge, MA: Basic Books (2005).

Gibson, D., Rosen, W., Stucker, B.: Business opportunities and future directions. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, 18, pp. 437–446, Springer (2010).

Glaser B.: Basics of grounded theory analysis. Mill Valley, CA: Sociology Press (1992).

Grover, V., Kohli, R.: Cocreating IT Value: New Capabilities and Metrics for Multifirm Environments. MIS Quarterly, 36, 1, pp. 225-232 (2012).

Gutierrez, K., Rogoff, B.: Cultural ways of learning: Individual traits or repertoires of practice. Educational Researcher, 32, 5, pp. 19–25 (2003).

Hatano, G., Inagaki, K.: Two courses of expertise. In Stevenson, H., Assume, H., Hakuta, K. (Eds.), Child development and education in Japan, pp. 262–272, New York, NY: Freeman (1986).

Hofferbert, S., Cahalane M., Finnegan P.: Gamification as an Architecture of Participation: An Investigation of an Innovation Maker Community (2015).

Hoftijzer J.: DIY and Co-creation: Representatives of a Democratizing Tendency. Design Principles & Practices, An International Journal 3 (6) (2009).

Holsti O.R.:Content analysis for the social sciences and humanities: Addison-Wesley, Reading, Mass (1969).

Honey, M., & Siegel, E.. Proceedings from the Innovation, Education & Maker Movement Workshop. New York Hall of Science (2010).

Kerlinger, F.: Foundations of behavioral research: Educational and psychological inquiry. Holt. Rinehart and Winston. Inc. John Wiley, New York (1964).

Koten, J.: Revolution in the making. The Wall Street Journal, June 11, R1 (2013).

Kuznetsov S., Paulos E.: Rise of the Expert Amateur: DIY Projects, Communities, and Cultures. NordiCHI '10, ACM, New York, NY, USA, 295-304 (2010).

Lande, M., & Jordan, S. S., & Nelson, J., Defining Makers Making: Emergent Practice and Emergent Meanings Paper presented at 2013 ASEE Annual Conference, Atlanta, Georgia. https://peer.asee.org/ 19382 (2013, June).

Leadbeater C.: We-Think: Mass innovation, not mass production. Profile Books (2008).

Lipson, H., Kurman, M.: Fabricated: The New World of 3D Printing. Indianapolis. IN: John Wiley & Sons (2013).

Martin, L.: The promise of the Maker Movement for education. Journal of Pre-College Engineering Education Research (J-PEER), 5, 1, p. 4 (2015).

Maye, L.: Sustainable DIY Technologies Servicing. Cultural Heritage. UD for Sustainability in Maker Communities. Workshop co-located with the Fourth International Symposium on End-User Development. ITU Copenhagen (2011).

McFedries, P.: The hobbyist renaissance. IEEE Spectrum. 2007, June.

McKinsey, http://tabsoft.co/1J2ji1m (2015).

McKinsey, http://bit.ly/1bWlTem, retrieved on 30.04.2015.

McKinsey, http://bit.ly/224Htlg (2015).

Merchant, N.: 11 Rules for Creating Value in the Social Era. Cambridge MA, Harvard Business (2012).

Miles, M.B, Huberman, A.M.: Qualitative Data Analysis. 2nd Ed., Newbury Park, CA: Sage, pp. 10-12 (1994).

Morris, M. G., Venkatesh, V.: Job characteristics and job satisfaction: understanding the role of enterprise resource planning system implementation. MIS Quarterly, pp. 143-161 (2010).

NN et al., "From smart work to Digital Do-It-Yourself: a research framework for digital-enabled jobs" accepted at itAIS workshop of Information Systems, Verona, Italy (2016).

Oxman N.: Digital Craft: Fabrication Based Design in the Age of Digital Production, in Workshop Proceedings for Ubicomp 2007: International Conference on Ubiquitous Computing. September 2007; Innsbruck, Austria; pp. 534-538 (2007).

Peppler, K., Bender S.: Maker movement spreads innovation one project at a time." Phi Delta Kappan 95.3, pp. 22-27 (2013).

Perkins, D., Tishman, S., Ritchhart, R., Donis, K., Andrade, A.: Intelligence in the wild: A dispositional view of intellectual traits. Educational Psychology Review, 12, 3, pp. 269–293 (2000).

Petrich, M., Wilkinson, K., Bevan, B.: It looks like fun, but are they learning? In Honey, M., & Kanter, D. E. (Eds.), Design. Make. Play. Growing the next generation of STEM innovators, pp. 50–70, New York, NY: Routledge (2013).

Quinn Patton M.: Qualitative Research & Evaluation Methods. Sage Publications, Thousands Oaks et al (2002).

Ratto, M., Ree, R.: Materializing information: 3D printing and social change", First Monday, 17 (7), July 2012

Ravarini, A., Strada, G., Leandri, M.: From smart work to Digital Do-It-Yourself: a research framework for digital-enabled jobs. Proceedings of itAIS 2016 conference, October 2016, Verona, Italy.

Rode, J. A., et al.: From computational thinking to computational making. Proceedings of the ACM UbiComp 2015.

Ryan, R. M., Deci, E. L.: Intrinsic and extrinsic motivations: Classic definitions and new directions.

Contemporary Educational Psychology, 25, 1, pp. 54–67 (2000).
Sharp, B., Dawes, J.: Is Differentiation Optional? A Critique of Porter's Generic Strategy Typology. In: Earl, P. (ed) Management, Marketing and the Competitive Process. Edward Elgar (1996).
Soep, E.: Participatory politics: Next-generation tactics to remake public spheres. Cambridge, MA: MIT Press (2014).
Spender, J.C., Kraaijenbrink, J.: Why Competitive Strategy Succeeds - and With Whom. In: Huggins, R., Izushi, H. Competition, Competitive Advantage, and Clusters: The Ideas of Michael Porter. Oxford University Press (2011).
Strauss A.: Qualitative analysis for social scientists. Cambridge, England: Cambridge University Press (1987).
Tanenbaum, J. G., et al.: Democratizing technology: pleasure, utility and expressiveness in DIY and maker practice. Proceedings of the SIGCHI 2013.
Tiwana, A.: Separating Signal from Noise: Evaluating Emerging Technologies. MIS Quarterly Executive, 13, 1, pp. 45-61 (2014).
Vansteenkiste, M., Simons, J., Lens, W., Sheldon, K. M., Deci, E. L.: Motivating learning, performance, and persistence: the synergistic effects of intrinsic goal contents and autonomy-supportive contexts. Journal of Personality and Social Psychology, 87, 2, p. 246 (2004).
Wing, J. M. "Computational thinking and thinking about computing."Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 366.1881, pp. 3717-3725 (2008):.
Yetton, P., Craig, J., Davis, J., Hilmer, F.: Are Diamonds a Country's Best Friend? A Critique of Porter's Theory of National Competition as Applied to Canada, New Zealand and Australia. Australian Journal of Management, 17, 1, pp. 89-120 (1992).
Yin, R. K.: Case Study Research: Design and Methods", Thousand Oaks, CA, Sage Publications (2003).
Zhang, X., Venkatesh, V.: Explaining Employee Job Performance: The Role of Online and Offline Workplace Communication Networks. MIS Quarterly, 37, 3, pp.695-722 (2013).
Jordan S., and Lande M., "Might young makers be the engineers of the future?", Frontiers in Education Conference (FIE) 2014 IEEE, pp. 1-4, 2014.

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