What are the Challenges and Enabling Technologies to Implement the Do-It-Together Approach Enhanced by Social Media, its Benefits and Drawbacks?

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ABSTRACT
Inspired by the Do-It-Yourself (DIY) movement, the Do-It-Together (DIT) collaborative approach was successfully trialed in 2018, hence opening the door to the application of User Driven Innovation for realizing product individualization. In the meantime, other megatrends like digitization, social media, sustainability, the circular economy, and collaborative consumption have pushed toward a renewed DIT approach for tackling social and societal issues. This article reports on an exploratory study dedicated to the

identification of challenges and enabling technologies to implement the DIT approach, as well as its benefits and drawbacks. This study is based on an extensive literature review that allowed us to identify 162 articles resulting in 38 most relevant selected articles and seven Product Life-Cycle (PLC) stages. Based on these PLC stages, all identified DIT challenges, benefits and drawbacks were collected from previous empirical work described in the selected articles. In terms of findings, relevant DIT challenges, benefits and drawbacks are consolidated in distinct tables with proper references. Regarding the enabling technologies for DIT implementation, only immersive technologies at the earlier PLC stage are addressed. The implementation analysis within other PLC stages and enabling technologies like Additive Manufacturing, Big Data, Artificial Intelligence and IoT have to be carried out in order to identify their particular benefits and drawbacks; however, this analysis is left to future work. This study has also revealed a lack of empirical studies addressing negative impacts while there is a plethora of published studies focusing solely on positive impacts.

KEYWORDS: Do-It-Yourself (DIY), Do-It-Together (DIT), User Driven Innovation (UDI), Social Media, New Product Development (NPD), Social Product Development (SPD), Social Manufacturing (SM), Circular Economy, Sharing Economy, Immersive Design, Immersive eXperience (IX), eXperience Design (XD)

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Industrial organizations, especially Small and Medium-sized Enterprises (SMEs), are currently facing several challenges, namely: (i) the fourth industrial revolution known as "Industry 4.0" (I4.0); (ii) an open innovation paradigm shift; (iii) digitization; (iv) collaborative consumption; (v) the new product individualization trend. According to Lecossier and Pallot (2017), the survival strategy of mature industrial companies, through their conventional incremental innovation and traditional organizational structure for preserving their market share, is no longer adequate to fulfil the ever-changing customer demand. On the one hand, consumers feel much more concern about societal issues like sustainability (Sikhwal, Childs, 2018) and individualized products based on cultural and gender differences, as well as other societal considerations (Kumar, 2007; Koren *et al.*, 2015; Sikhwal, Childs, 2019). On the other hand, businesses are moving toward a more collaborative and responsible attitude regarding both social and societal issues. Inspired by the DIY movement and DIT collaborative culture (Hirscher *et al.*, 2018) promoted by the Web 2.0 (*e.g.*, User Content Creation, crowdsourcing), we elaborate on renewing the DIT approach according to the social media impact on New Product Development (NPD). Such a new DIT approach combines several socially extended concepts including Social Ideation

(Schleich, Prell, 2015), Co-creation (Ramaswamy, Gouillart, 2010), Social Product Development (SPD) (Piller *et al.*, 2011) and Social Manufacturing (SM) (Jiang *et al.*, 2016) in the context of User Driven Innovation (Pallot, 2009; Füzi, 2013). This is an opportunity for industrial organizations, especially SMEs, independent experts, such as: designers, architects, and makers, and consumers, to overcome these above-mentioned challenges in implementing this renewed DIT approach thanks to enabling technologies like Additive Manufacturing (AM), eXtended Reality (XR), Big Data (BD) and Artificial Intelligence (AI).

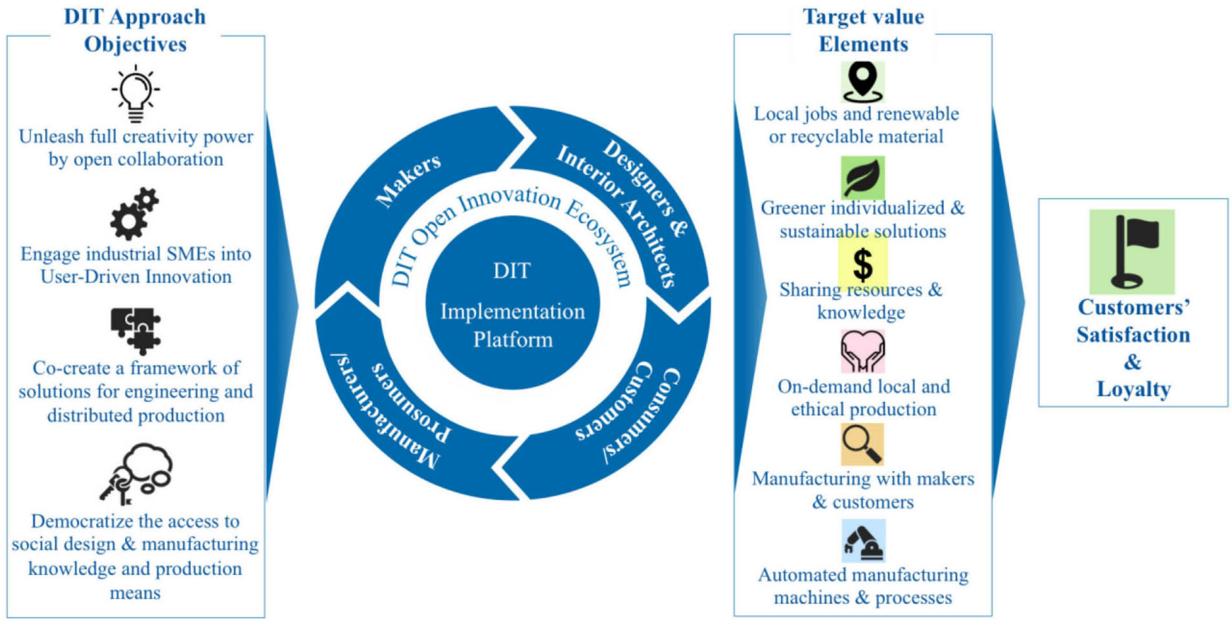
The DIT approach is intended to be generic enough to be applied within any business sector where consumers are engaged in the innovation process. The furnishing business sector is a perfect example, combining the furniture sector and interior design personalization. In fact, home owners are increasingly looking for opportunities to contribute to individualization in terms of furnishing their house or apartment while decorating and providing it with furniture and fittings. In fact, this is not restricted to furniture and interior design as it could also include furnishing smartification, while taking into account sustainability principles described in the report FURN360 (2018). This exploratory study is intended to identify DIT implementation challenges to be tackled, induced benefits, and eventual drawbacks, while anticipating to what extent enabling technologies would contribute to overcoming these challenges. In this study, a particular focus is given to immersive eXtended Reality (XR) in the context of social ideation and co-design, named "Immersive Design" (Dietrich *et al.*, 2019). Our motivation comes from the willingness to obtain more knowledge and comprehensiveness about the implementation of this renewed DIT approach into a twin digital and physical platform. This twin DIT platform will be trialed in the furnishing business sector and interior design including smartification. The furniture sector is a rather good example of a traditional market that could evolve toward an Immersive Design ecosystem; especially for home owners that increasingly wish to be engaged in the design and production of personalized furniture according to their interior design requirements and the emergence of appliances and other electronic means, driven by the Internet of Things (IoT).

The DIT approach disrupts the traditional industrial setup in which designers are highly valued employees whose bursts of inspiration must be jealously kept within the brand walls. In our vision, designers and interior architects are freelancers while customers are both producers and consumers. This dual role of customers, which was already identified in 1980 by Toffler through the name "prosumers", leverages the DIT platform in proposing their personalized concepts while getting feedback from other customers.

They could even contribute by enhancing customers' ideas and interacting with potential suppliers (*e.g.*, manufacturing SMEs or FabLab makers) so that the new product design grows faster and much closer to the actual expectations of its future users. Makers and prosumers possess the fabrication knowledge related to the specific production machines they regularly use (*e.g.*, 3D printers, computer numerical control – CNC). Hence, their role is more about prototyping designed parts that can, once validated, eventually be transferred to a local production site like a FabLab or an SME manufacturer for a higher quality production, depending on the amount to be produced. However, prosumers could be more interested in a one-of-a-kind manufacturing approach that perfectly fits with FabLab self-production through 3D printers. Additionally, the DIT approach establishes regional industrial innovation hubs that are meant to let customers and professionals (*e.g.*, freelancers), involved in the finalization of a new design, get their hands on all the selected elements (materials, shapes, technical solutions) in experimenting with the virtual (XR technologies) or physical (*e.g.*, 3D printing) prototyping and manufacturing process. It relies on a distributed network of qualified makers and small local producers making their production capabilities available to the ecosystem; thus, at the same time, creating new business opportunities for them and establishing a virtual and dynamic production system that can locally produce individualized products according to each consumer's specific context and expectations.

The overall DIT-enabled ecosystem also achieves a seamless adoption into each factory operation, thanks to standardization of the product's blueprints and of their processing into production instructions that are compatible with a broad set of working machines. The DIT approach, in terms of objectives and targeted value elements, is visually represented as a vision to attain (Figure 1). These objectives are operatively pursued in developing the following elements: (i) Co-creation digital platform, establishing a digital melting pot where a market-aware designer's creativity and talent closely interact with customers while being influenced by their ideas and needs; (ii) Compatibility layer, translating the co-created smart-object design into machine production instructions toward shortening the time-to-market of new concepts; (iii) Industrial production network, offering close-to-the-customer local production capabilities and technical know-how for flexible, sustainable and open smart-object manufacturing, even in small lots or in one-of-a-kind; (iv) Industrial innovation hubs, acting as the front-end of the whole system where gaps between digital design and hard manufacturing techniques are filled by providing hands-on experience and a value network cross-fertilization of know-how.

Figure 1 – DIT approach objectives and targeted value elements (Extended by authors from an original diagram initiated by Marc Pallot during the INEDIT project proposal)



We draw on the work of Hämäläinen *et al.* (2018) to overcome barriers to sustainability toward personal fabrication and the emerging concept of social manufacturing. These provided a summary table describing 13 concepts, from distributed manufacturing to the platform economy, related to personal fabrication and distributed production. Among these concepts, between mass customization and peer production, there is the concept of personalization represented by the following trio: "design, choose & buy". Here, we suggest including the concept of individualization (Koren *et al.*, 2015; Sikhwal, Childs, 2018, 2019); that is, going one step further as it represents prosumers co-creating value, through ideation, design and fabrication, while obtaining the expected resulting experience. In our vision, we interpret the individualization concept as another trio: "experience, produce & adopt". Certainly, there is no need to necessarily "choose" between different options as it is designed to fit in with the particular customer's expectations. Then, "buy" is more intended to acquire a product on a shelf rather than to pay for a co-creation experience, which includes ideation and design iterations, leading to the expected solution.

Furthermore, co-creation also means that all stakeholders, including users and suppliers, share knowledge and contribute to creating new knowledge (Ramaswamy, Gouillart, 2010; Pallot, Pawar, 2012). Nowadays, there are mobile apps allowing people to easily capture a 3D representation of their rooms directly from their smartphone camera. Then, there are immersive technologies, especially XR, which include Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) devices, enabling people to create and concurrently experience alternative solutions. The eXperience Design (XD) iterative process is particularly appropriate for this kind of immersive design where stakeholders are immersed into a virtual 3D representation in order to live a close to real experience of their living environment (Dietrich *et al.*, 2019). According to iSMA (2014), social marketing originates from commercial marketing and seeks to create marketing concepts and techniques influencing behaviors that benefit both individuals and society. Sikhwal and Childs (2018) consider the concept of Mass Individualization (MI) as a new product design paradigm. They present individualization as a product that is highly personalized reflecting usage requirements and ensuring a longer product life cycle. They argue that this new product design paradigm serves product adaptability, upgradability, and sustainability, while meeting usage requirements.

Besides introducing the background, motivation and purpose of this exploratory study toward the implementation of a renewed DIT approach enhanced by social media impacts on the NPD, the extensive literature review is presented before unveiling the findings through several tables dedicated to DIT challenges, benefits, and drawbacks. Finally, we conclude in discussing the limitations of this study and future work while summarizing its main contribution.

Methodology

In the current body of knowledge and besides the "NPD and social media" research stream, we have identified two other research streams that would mainly match the DIT approach, namely: "Social Product Development" and "Social Manufacturing". The first one contributes to the study of the social media impact on NPD within the Open Innovation paradigm, while the second one contributes to the study of the social media impact on manufacturing within the I4.0 smart and individualized manufacturing paradigm. Therefore, it would make sense to bring common knowledge about the challenges facing DIT implementation, as well as potential benefits and eventual drawbacks. The goal is also to better understand how enabling technologies could fit with the implementation of the DIT approach. Second, sometimes it appears that concepts are awkwardly defined while the use of synonyms brings even more confusion. Furthermore, there is a lack of empirical studies on the assessment of NPD with social media, SPD, and SM in terms of implementation challenges, induced potential benefits, and eventual drawbacks. It also appears that very few studies related to the DIT research domain investigate potential negative impacts (*e.g.*, drawbacks, disadvantages, shortcomings) while there are plenty of publications which rather present the positive impacts (*e.g.*, benefits, advantages) as reported in Table 1. The main goal of this study is to deliver a comprehensive picture of DIT implementation in terms of challenges to be overcome by enabling technologies, induced benefits, and drawbacks. This is intended to lead to a better understanding of individualized product business both in terms of opportunities and risks for prosumers, designers, interior architects, makers, and SMEs operating in the furnishing sector. This could then be adapted to other business sectors facing a similar growing demand of individualized products.

A research process, based on a systematic literature review, was intended to identify: (i) the DIT-relevant publication streams and databases; (ii) challenges, enabling technologies, potential benefits and eventual drawbacks for implementing the DIT approach on the basis of social media applied to NPD in the context of the circular economy and the sharing economy. A multi-keyword search derived from the application of social media within the different product life-cycle stages was carried out among different publication databases (IEEE Xplore, JSTOR, Blackwell, Emerald, Springer, sciencedirect, worldscientific). In the meantime, through the use of an advanced search, “Social Product Development” and “Social Manufacturing” were emerging as relevant publication streams. A search for relevant previous work was based on the combination of specific keywords, namely: “New Product Development” and “social media” or “Social Product Development” or “Social Manufacturing”. Other complementary keywords: “challenges”, “benefits” and “drawbacks”, which represent the most important elements of the topic under scrutiny, were included in this search for previous work and were mapped against a Search, Appraisal, Synthesis and Analysis framework (Grant, Booth, 2009). This literature review was intended to bring the necessary elements for answering the following research questions: (RQ1) What are the DIT implementation challenges to be overcome in the context of the circular economy and the sharing economy? (RQ2) What are the potential benefits induced by DIT implementation? (RQ3) What are the potential drawbacks induced by DIT implementation? (RQ4) What are the enabling technologies for overcoming the DIT implementation challenges?

The search process was executed on the main keywords (NPD and social media, SPD, SM) appearing in the title that gave the following number of articles for each of the publication streams: “NPD”: 32, “SPD”: 32, “SM”: 98, which represented overall 162 articles. Having the search done through keywords appearing in the title resulted in a limited, but extremely relevant, number of articles. All selected articles were scrutinized for collecting evidence leading to the identification of challenges, induced benefits and drawbacks, or synonyms like advantages or disadvantages or shortcomings.

Table 1 **– Characteristics of selected articles**

Authors	*Year*	*DIY & DIT*	*NPD & sm*	*SPD*	*SM*	*Challenges*	*Benefits*	*Drawbacks*	*Enabling Techno*	*Economy type*
Abhari *et al*	2020		X	X		X	X			S
Ahmed *et al.*	2020		X			X	X		VR	
Ahmed *et al.*	2019		X			X	X		IoT	
Alcácer & Cruz-Machado	2019		X			X	X		AM, AR, BD, IoT, I4.0	
Bharati *et al.*	2020		X			X	X	X		
Bressanelli *et al.*	2017		X			X	X	X	IoT, AM	C, Se
Calabrese *et al.*	2020		X			X	X	X	AM, AR, VR, BD, IoT, I4.0	D, S
Cheng & Krumwiede	2018		X			X	X	X	VR	
Cheung & To	2020		X			X	X			
Corona *et al.*	2019		X			X	X	X		C
Ford & Despeisse	2016				X	X	X		AM	
Giannakis *et al.*	2020		X			X	X	X	BD, AI	
Gordo Lopez *et al.*	2021		X			X	X			C, P, S
Guo & Jiang	2019				X	X	X			
Haleem & Javaid	2019		X			X	X		AM, VR, AR, BD, AI, IoT, I4.0	
Hamalainen & Karjalainen	2017				X	X	X	X	AM	S
Hamalainen *et al.*	2018				X	X	X	X	AM	P, S
Hirscher *et al.*	2018	X			X	X	X			
Jiang *et al.*	2016		X		X	X	X	X	AM, AR, BD, AI	
Koren *et al.*	2015		X		MI	X	X	X		A
Koren *et al.*	2013		X		MI	X	X	X	VR, AR	
Lanz & Järvenpää	2019	DIY	X		X	X	X	X	AM	C, O, S
Liu & Kop	2015		X			X	X	X		
Mahajan *et al.*	2021	X				X	X	X	IoT	
Mohajeri *et al.*	2014		X		X	X	X		AM, VR	
Naghshineh *et al.*	2021				X	X	X	X	AM	C
Pallot *et al.*	2017		X			X	X	X	XR	
Pereira Pessoa	2020			X		X	X		AM, AR, BD, AI, IoT, I4.0	
Rautela *et al.*	2020		X			X	X		VR	
Rautela *et al.*	2019		X			X	X		AR, BD	
Roberts *et al.*	2014		X			X	X			
Sikhwal & Childs	2018		X		MI	X	X	X		C
Tseng *et al.*	2010		X			X	X		XR	E
Wang *et al.*	2021		X			X	X	X		C
Yin *et al.*	2020				X	X	X		IoT, AI	C
Zhan *et al.*	2021		X			X	X	X	VR, BD, AI	C, D, S
Zhan *et al.*	2020		X	X		X	X	X	BD	
Zhan *et al.*	2018		X			X	X	X	VR, BD, AI	

A: *App economy;* C: *circular economy;* D: *Digital economy;* E: *Experience economy;* P: *Platform economy;* S: *Sharing economy;* Se: *Service economy.*

The filtering is based on secondary keywords: challenges, benefits, drawbacks or synonyms like advantages or disadvantages resulted in 38 selected articles that are presented with their characteristics in Table 1. Another search was executed on the remaining selected articles in order to identify the enabling technologies and economy types also shown as characteristics in the same table. The advanced search of relevant articles was executed in the 2010-2021 time range, as these concepts are pretty recent as they are linked to the use of social media within the different Product Life-Cycle (PLC) stages as they are described in the next section (FFE, co-design, open manufacturing, co-marketing, field testing, green logistic, social reuse). The grouping of identified challenges, induced benefits, and possible drawbacks is based on their location within PLC stages.

Findings

DIT Stages

The social dimension of the DIT approach reflects the effort to engage external participants, through the use of social media, with different expertise along the product life-cycle, such as independent designers, interior architects, makers, suppliers and especially customers or prosumers. There are several stages that make up this DIT-related PLC as presented in the selected articles. On the DIT economical dimension, there are the digital economy - including the platform economy, experience economy, and sharing economy – the knowledge economy, and the circular economy, which impact the DIT NPD process. Each of the seven identified PLC stages is briefly described in Table 2.

Co-creation or social ideation reflects the early stage of PLC, which is known as the Fuzzy Front-End (FFE) stage (Lecossier *et al.*, 2019; Kim, Wilemon, 2002), in which all stakeholders, including customers, co-create ideas that bring value. The second PLC stage is named co-design; however, nowadays it partly overlaps with co-creation for the rapid conceptualization of ideas and usage scenarios including virtual prototyping through the use of an iterative XD process (Pallot *et al.*, 2020); and manufacturing for issuing physical prototypes in order to validate the concepts and start the industrialization phase. The third PLC stage is open manufacturing, in which individuals (*e.g.*, makers, prosumers) can by themselves produce a one-of-a-kind through the use of additive manufacturing (*e.g.*, 3D printers), as is done, in fact, for physical prototyping, or in using small CNC robotized production units. The fourth PLC stage, co-marketing or social marketing, is about the marketing communication mix including Word-of-Mouth (WoM) and influencer marketing, where social media play an important role. Social commercialization, the 5th PLC stage, is more about field testing to make the new product error-free and launching it. This stage also includes the validation of the positioning and marketing mix while collecting feedback from customers about product performance, degree of usability, experience and level of satisfaction, as well as remaining issues. Then, the green collaborative logistics, 6th PLC stage, represents crowdsourced activities such as product maintenance (*e.g.*, regular upgrades) and repairing (*e.g.*, makers) for a longer life cycle that could require producing parts locally on demand through 3D printing; as well as the reverse logistics for taking care of retired products. Finally, there is the 7th PLC stage, named "social reuse", for ensuring the lowest possible level of product waste, through crowdsourced activities like refurbishing, repurposing, and possibly upcycling.

Table 2 **– Description of product life-cycle stages**

N°	***Stage***	***Description***
S1	Co-creation (Social Ideation)	(*) in co-creation in order to facilitate the emergence of new ideas, their evaluation and validation through the use of diversity and appropriate creativity tools and methods. Better insight into the needs of the consumers. Knowledge Sharing.
S2	Co-design Open Design	(*) in co-designing different alternatives of potential solutions, exploring and experimenting their usage scenarios through the co-evaluation of mock-up and prototype. This includes the need for rich designs in individualization and high-quality local materials for sustainability, repair, reuse, remanufacture and recycling.
S3	Open Manufacturing	(*) in making sure that everyone, especially makers and prosumers, can access and feed, with digital design (*e.g.*, CAD drawings), autonomous production machines (*e.g.*, 3D printers, robotized production units) and assembling the instructions and necessary tools & equipment for quality control. Recycling production waste to make new production resources.

N°	**Stage**	**Description**
S4	Co-Marketing (Social marketing)	(*) in contributing to the co-creation of value and anticipated UX including the marketing communication mix (customer feedback to firms and to other customers) through perceived performance and word-of-mouth as well as customer motivational orientation and influencer marketing toward customer satisfaction. Relating social media to the seven Cs (content, community, conversation, capital [social], culture, collaboration, and conversion). Originating from commercial marketing, social marketing seeks to "*develop and apply marketing concepts and techniques to influence and support behaviours that benefit individuals and society*" (iSMA, 2014).
S5	Social Commercialization	(*) in having customers provide their first-hand feedback on product usability, product performance, potential problems concerning the prototype, and the positioning and marketing mix of the new product. Customer's reactions to these areas help firms to make new products error-free, to improve product positioning and the marketing mix of the new product.
S6	Green logistics, Reverse logistics	(*) in third-party (crowdsourced) logistics provides the solution to innovate the fulfilment process. Customers also provide feedback for the platform services that can be used to improve or innovate its services. An e-commerce platform provides instant maintenance, repair, and delivery services that closes the gap between the producer and the customer.
S7	Social Reuse, Refurbishment, Repurposing	(*) in ensuring the lowest level of product waste through reusing, repairing, refurbishing, remanufacturing, or recycling. A circular business model entails a reverse logistics that is able to return products from users to producers, involving the above-mentioned activities. Reuse is preferable to recycling, since much of the value still remains with the components. Easier disassembling for makers and prosumers.

(*) Engage external participants - through the use of social media - such as: independent designers, interior architects, makers and especially prosumers

S1*: Rautela et al., 2020; Abhari et al., 2020; Cascini et al., 2020; Zhan et al., 2020; Lanz, Järvenpää, 2019; Zhu et al., 2017; Roberts et al., 2016; Mukhat et al., 2012.*

S2: *Rautela et al., 2020; Lanz, Järvenpää, 2019; Aral, Walker, 2011; Zhu et al., 2017; Roberts et al., 2016; Govindaraju, 2020; Bressanelli et al., 2017.;*

S3*: Lanz, Järvenpää, 2019; Ahmed et al., 2020; Hirscher et al., 2018; Jiang et al., 2016; Gogineni et al., 2020; Govindaraju, 2020; Bressanelli et al., 2017; Yin et al., 2020; Naghshineh et al., 2021.*

S4*: Dougherty, 2012; Ertz et al., 2016; Umezawa et al., 2017; Dietrich et al., 2019; Cheung, To, 2020; Rautela, Singhal, 2020.*

S5*: Glessner, 2012; Roberts, Candi, 2014; Wang et al., 2020; Chang, 2019; Pienaar et al., 2019; Yang et al., 2019; Rautela et al., 2020; Liu, Kop, 2015; Cheung, To, 2020.*

S6*: Santoso et al., 2020; Gogineni et al., 2020; Cheng, Krumwiede, 2018; Wang et al., 2021.*

S7*: Bressanelli et al., 2017; Hirscher et al., 2018; Govindaraju, 2020; Corona et al., 2019; Wang et al., 2021; Ford, Despeisse, 2016; Gordo Lopez et al., 2021.*

Identified DIT Challenges and Benefits

In the context of the DIT approach, each PLC stage has different challenges to be overcome leading to potential benefits and possible drawbacks as presented in the following tables. However, it should be noted that all the benefits and drawbacks mentioned are the ones identified during the literature review. A first statement about this particular literature review is that there are far more published studies presenting induced benefits rather than drawbacks. It explains the breakdown of the presentation of all identified challenges and benefits into several tables while there is only one table about drawbacks. Besides the obvious DIT platform (implementation of the DIT approach) of the overall benefit of democratizing co-creation, design and manufacturing (Hirscher *et al.*, 2018), people face numerous issues/challenges to implement an effective distributed innovation and collaboration mode. Individualized products and on-demand production partly characterize social manufacturing, which encourage open innovation through social collaboration and intellectual resource sharing (Jiang *et al.*, 2016). The DIT platform is based on the sharing economy principle of borrowing or renting assets (*e.g.*, 3D printers for prototyping, head-mounted-displays for immersive design) owned by someone else (Lanz, Järvenpää, 2019), which represents other major benefits not only from easier access to shared resources and lower usage cost but also from shared knowledge and skills.

Regarding social ideation, Zhan *et al.* (2020)'s findings show that while social media facilitates information search and knowledge acquisition, the degree of product ideation success mainly relies on the capacity to seek inspiring and reliable knowledge. This knowledge relies on both internal and external resources and information that are crucial for the innovativeness and success of NPD. They are pretty prolific in terms of identifying the key benefits grouped within three NPD stages, as shown in their Table 1. All the discussed benefits within PLC stages S1 to S3 that contribute to the overall benefit of the democratization of co-creation, design and manufacturing were included in Table 3. Regarding the other PLC stages from S4 marketing to S7 re-use, one of the major benefits is to avoid the traditional end-of-life leading to the continuous increase of waste. According to Lanz and Järvenpää (2019), "*the circular economy aims at reducing solid waste, landfill, and emissions through activities such as reuse, remanufacturing, and/or recycling*". Other significant benefits about S4 social marketing include stronger customer engagement through participation to co-creation activities (Pallot, Pawar, 2012) and emotional attachment to co-designed products (Hirscher *et al.*, 2018). As for social collaborative commercialization, Zhan *et al.* (2020)'s findings show that social media platforms bring a significant benefit as they

Table 3 **– Description of DIT stages 1 to 3 challenges and benefits**

St	***Challenge***	***Concepts***	***Benefits***	***Ref***
S1 Social Ideation (Co-creation)	Enabling co-creation among diverse cultures, profiles, skills and roles	DIT, maker and presumption movements	• Facilitate the emergence, filtering and selection of new ideas leading to inventions and innovations. • Enhanced sense of belonging in customers. • Increase the degree of customer satisfaction through their empowerment in decision-making. • Ensure lower failure rates. • Result in a higher rate of product acceptance/adoption meaning more successful products.	S1B1
	Engaging all stakeholders in co-creation	DIT Social Media for NPD (SPD)	• Reduce the risk of adopting the wrong product concepts • Allow rapid speed of communication • Develop innovative products • Generate new ideas • Ensure customer base growth	S1B2
	Sharing knowledge in Co-creation	Organizational learning, DIT Social Media for NPD (SPD)	• Solve problems and achieve competitive advantages • Generate new knowledge and apply to where it is required for later use and integration • Result in high levels of media-rich modalities for collaboration • Offer a powerful means of knowledge acquisition and integration for organizational learning • Leverage social media to search for new knowledge • Provide multiple sources of knowledge through integration, guiding to action • Result in an in-depth understanding of relationships among knowledge search patterns	S1B3

St	*Challenge*	*Concepts*	*Benefits*	*Ref*
S2 Social Co-Design	Sharing and extracting knowledge and perceptions from external stakeholders	Open forms of NPD, virtual communities and online platforms	• Enhance the organization's knowledge to be embedded in the product R&D • Deliver more valued products conversely to companies creating products in isolation • Integrate its design programme with a variety of social media channels • Result in a community-powered social commerce platform • Utilize social media data and reporting capabilities to produce more data-driven products • Rapid development of new products that have strong market attractiveness	S2B1
	Enabling innovation among designers, makers, prosumers & producers	DIT Social Media for NPD (SPD)	• Improve innovativeness and efficiency • Reduce costs • Ensure better adoption of products • Improve customer relationships	S2B2
	Increase Product Life-cycle	DIT Social Media for NPD (Social Product Development), Open Design	• Enable consumers to become value co-creators through the entire value chain • Generate deep emotional satisfaction with consumers as they co-create meaning by making a product with their own skills • Make consumers satisfied due to their expended effort and success in doing something by themselves • Increase customers' emotional attachment to their product while increasing its value, making it less likely to be discarded • Make consumers more responsible by valuing their goods for longer, and slowing down consumption cycles	S2B3

St	***Challenge***	***Concepts***	***Benefits***	***Ref***
S3 Open Manufacturing	Make the production systems more flexible, autonomous and collaborative (I4.0)	DIT Additive Manufacturing, Open Manufacturing	• Decrease data processing due to parts directly manufactured from CAD data files • Greater customization without extra tooling or manufacturing cost • Increase the capacity to manufacture complex geometries • Manufacturing of hollow parts (achieving less weight) or lattice structures • Maximization of material utilization for the "zero waste" approach • Smaller operational footprint toward manufacturing a large variety of parts • On-demand manufacturing and excellent scalability. Recycle used material (*e.g.*, plastic, wood)	S3B1
	Disrupt current mass production and mass customization	Individualized Production, Democratized Manufacturing	• Provide opportunities to re-organize manufacturing locally in a democratized and individualized production • Reduce manufacturing costs through the sharing of manufacturing resources among individuals within a makerspace or a FabLab • Easier input mode, self-production and assessment • Promote a decentralized and non-hierarchical structure of production within the sharing economy • Shift the economy toward the sharing economy through the diffusion of open hardware in manufacturing	S3B2
	Democratize access to machines and environment respect	DIT approach, FabLabs, Resource Efficiency	• Open access to makerspaces and production machines (*e.g.*, FabLabs) • Validating production quality through successive product prototypes (*e.g.*, 3D printing) • Reducing resource flow through the design of longer-life products or an extension of the product life • Closing the resource loop, through the design of products that are easy to reuse and recycle	S3B3

S1B1*: Rautela et al., 2020; Abhari et al., 2019, 2020; Lanz, Järvenpää, 2019; Zhu et al., 2017; Roberts et al., 2016; Pallot et al., 2010;*

S1B2*: all references in Table 1 and Zhan et al., 2020.*

S1B3*: Rojo et al., 2018; Nguyen et al., 2015; Hemsley, Mason, 2013.*

S2B1*: Sigala, 2012; Piller et al., 2011; Cooper, 2016; West et al., 2014; Du et al., 2016; Manyika et al., 2013; Zhan et al., 2018; Hoyer et al., 2010; Roberts et al., 2016.*

S2B2*: all references in Table 1 in Zhan et al., 2020.*

S2B3*: Hirscher et al., 2018; Mohajeri et al., 2014.*

S3B1*: Alcácer, Cruz-Machado, 2019; Li, 2018; Tofail et al., 2018; Jiang et al., 2016.*

S3B2*: Niaros et al., 2017; Seravalli, 2012; Anderson, 2012; Ahmed et al., 2020; Hirscher et al., 2018; Jiang et al., 2016; Govindaraju, 2020; Bressanelli et al., 2017.*

S3B3*: Hirscher et al., 2018; Jiang et al., 2016; Bocken et al., 2016.*

Table 4 – **Description of DIT stages 4 to 7 challenges and benefits**

St	*Challenge*	*Concepts*	*Benefits*	*Ref*
S4 Social Marketing S5 Social Commerce	Co-create product positioning and marketing mix aligned with environmental facet	DIT approach, eXperience Design, sustainable practices and ethical awareness	• Capture first-hand customers' feedback on anticipated experience impacting positioning and marketing mix • Replace the traditional marketing motto from "Make people want things" to "Make things people want" • Changed product consumption habits in reflecting people's willingness to undertake more sustainable practices • Increased ethical awareness in challenging product consumption practices • Reduce the fast disposal of product waste in changing consumption practices	S4B1
	Co-create the product's emotional and economical facets	DIT and PD approaches, Product Individualization, Sustainable development and Collaborative Making	• Value emotionally when consumers engage passionately with objects during co-creation • Changed behavior of consumers and aspirations as they feel more than just consumers through shared experiences • Contribute to building a story captured within the made product • Increased product value when participants achieve deeper individualized person-product attachment (personal memories) • Create new business opportunities where a network of people creates a new business logic • Increased sustainability awareness	S4B2

St	***Challenge***	***Concepts***	***Benefits***	***Ref***
S4 Social Marketing S5 Social Commerce	Co-create product social facet	Social interaction, integration, trustable relationships and empowerment	• Create social value - includes social interaction, integration, and empowerment – in the collaborative design process • Generate wellbeing through social interaction in face-to-face workshops where participants are "making together" • Stimulate the willingness to adopt individualized products through community belonging • Establish strong trustable long-lasting relationships in expanding a kind of network of weak ties	S4B3

St	***Challenge***	***Concepts***	***Benefits***	***Ref***
S4 Social Marketing S5 Social Commerce	Co-create product technological facet	Maker Movement, Makerspace, Shared spaces, Prototyping	• Increase social capital by making collective action and the professionalization of platforms more sophisticated • Create experiential value elements like collective empowerment, learning through skill-sharing, and self-enhancement • Emphasize collective empowerment and satisfy consumer needs through alternative experiences • Replace the desire to consume more. • Generate participants' experience with the feeling of "joy" in co-creating an individualized product. • Change the prosumers' role to that of a teacher, advisor, and recommender for others as they increase their skills over time	S4B4
	Make the commercialization more collaborative	DIT approach, market testing and market commercialization	• Create DIT-related segmentation through knowing how that new product will survive with # user communities • Provide an opportunity to develop services for young, environmentally-aware consumers offering an emotional experience • Decrease the effect of an emotional experience created by fashion purchases • Offer practical and innovative ways of interacting with a wide range of consumers • Facilitate communication that traditional methods cannot provide and which allow them to be closer to target markets • Acquire an in-depth understanding of how a new product fits with different types of consumers	S5B1

St	Challenge	Concepts	Benefits	Ref
S4 Social Marketing S5 Social Commerce	Enable a more effective and efficient product testing & launch	DIT approach, Customer Relationship Management	• Rapidly provide first-hand customer feedback on product usability, and product performance • Identify potential problems concerning product testing and the positioning & marketing mix of the new product • Identify product defects early and reduce costly rework and redesign • Make new products error-free, improve product positioning and the marketing mix according to customers' reaction • Minimize investment in internal product testing procedures by engaging user communities in beta product testing	S5B2
	Increase the degree of technology acceptance and product adoption	DIT approach, Customer Behavior	• Affect customer perceptions and therefore increase the likelihood of new product acceptance and a successful launch • Enhance positive "word of mouth" communication affecting the customer's attitude and purchasing decision • Increased rate of product adoption by customers through mutual influence • Extended process effectiveness reflected in enhanced profit margins, sales growth, market share, RoI, return on assets	S5B3
S6 Logistic	Make the logistics more collaborative and environmentally-friendly	DIT approach, Local Delivery	• Contribute to reducing the amount of produced CO^2 in avoiding shipping raw material and products from abroad • Reduce the level of product waste by extending the product life through local maintenance and repair (self)-services • Distribute knowledge on maintenance and repair to prosumers • Enable the provision of regular upgrades	S6B1

St	*Challenge*	*Concepts*	*Benefits*	*Ref*
S7 Social Reuse	Ensure the lowest level of product waste	DIT circular economy and environmental sustainability	• Reduce product waste through reusing, repairing, refurbishing, remanufacturing, or recycling when there is no other solution • Involve a reverse logistics able to return products from users to local producers • Decrease as much as possible the amount of recycling since much of the value still remains with the components • Make product disassembling and repair for all stakeholders and especially makers and prosumers easier	S7B1
	Co-create Sustainability Value	DIT and PD approaches	• Create social and environmental value benefiting the individual owners or the community • Increase product life cycle through reuse and appropriate local material selection • Reduce fast product disposal by introducing more sustainable practices and influential factors for consumer behavior • Reinforce product emotional attachment in the long run through experiential value generated by and for the user • Increase the repair option by sharing knowledge among makers and prosumers as well as democratized parts production	S7B2

St	***Challenge***	***Concepts***	***Benefits***	***Ref***
S7 Social Reuse	Apply regulations concerning environmental protection and dismantling safety	DIT Sustainability regulation and environmental protection	• Solve ethical concerns regarding the reuse network and ecosystem • Verify quality assurance of the recycling process • Validate recycling quality through measuring emissions & produced energy • Control the recycling process and quality through the sharing of assessment resources (equipment, methods and tools) • Applied regulations concerning occupational safety in dismantling and recycling • Validate the Machine Directive for safe working conditions especially in the case of distributed local recycling	S7B3

S4B1*: Dougherty, 2012; Henard, Szymanski, 2001; Adams, 2006; Ertz et al., 2016; Umezawa et al., 2017.*

S4B2*: Hirscher et al., 2018; Pallot, Pawar, 2012; Rautela et al., 2020.*

S4B3*: Hirscher et al., 2018; Pallot, Pawar, 2012; Herrera, Hidalgo, 2018; Mahmoud et al., 2018; Rautela et al., 2020.*

S4B4*: Hirscher et al., 2018; Pallot, Pawar (2012); Rautela et al., 2020.*

S5B1*: Henard, Szymanski, 2001; Nambisan, 2002; Glessner, 2012; Rautela et al., 2020.*

S5B2*: Roberts, Candi, 2014; Henard, Szymanski, 2001; Wang et al., 2020; Chang, 2019; Pienaar et al., 2019; Yang et al., 2019; Rautela et al., 2020.*

S5B3*: Kaplan, Haenlein, 2012; Ind, Coates, 2013; Fuller et al., 2009; Wang et al., 2020; Abdolmaleki, Ahmadian, 2016; Seyyedamiri, Tajrobehkar, 2019; Sheng et al., 2013; Rautela et al., 2020.*

S6B1*: Bocken et al., 2016; Gaiardelli et al., 2008; Go et al., 2015; Bressanelli et al., 2017; Santoso et al., 2020.*

S7B1*: Bressanelli et al., 2017.*

S7B2*: Hirscher et al., 2018.*

S7B3*: Hirscher et al., 2018.*

facilitate reflective learning and knowledge transformation within all PLC stages and especially during the product testing and launch process. As for the PLC stage S6 Social Logistic, Bressanelli *et al.* (2017) argue that reverse supply chain and second-hand markets are not sufficiently developed yet for the circular economy to have a chance to succeed (Table 4).

Identified DIT Challenges and Drawbacks

In terms of drawbacks, as explained earlier, it appears that there is a certain scarcity of scholars studying the negative impacts of social media on NPD from social ideation to social manufacturing.

Nonetheless, Lanz and Järvenpää (2019) seem to be the most prolific scholars to have identified social design and manufacturing drawbacks, especially in terms of product quality, mainly due to the lack of verified quality assurance. They also discussed other aspects such as respect for safety regulations, customer rights, and care about potential product defects, and conformity to IPRs in relating the fact that prosumers rarely perceive reverse engineering as a violation of patented products. They also criticize the lack of concern about environmental sustainability in production, especially in the case of additive manufacturing (3D printing), arguing that the impact in economic terms on sustainability as described in circular economy frameworks is rarely considered in the literature. Finally, they have identified another drawback considering respect for occupational safety regulations, especially in the case of locally distributed manufacturing. As shown in Table 5, there was a lack of identified drawbacks in the selected articles regarding stages S4, social marketing, and S5, social commercialization. Roberts *et al.* (2016) pointed out that using social media to engage customers in product ideation and design could result in imitative and unimaginative products due to mismatching technology readiness and development strategies that are unaligned to current customer requirements. There are other transverse drawbacks due to digitization, such as knowledge leakages (Alberti, Pizzurno, 2017).

Table 5 – **Description of DIT PLC stages challenges and drawbacks**

Stage	***Challenge***	***Concepts***	***Drawbacks***	***Ref***
S1 Social Ideation	Engaging all stakeholders in co-creation	DIT Social Media for NPD (SPD)	• Involving customers in product ideation and design can result in imitative and unimaginative products • Co-creation with customers might be more suitable for young experimental consumers and not for all • Could require implementation of different social media applications for different product ideation • The use of social media differs with the levels of technology readiness and alignment of product development strategies to current customer requirements	S1B1
S2 Social Co-Design	Ownership, Reverse Engineering and Product Life-cycle & Reuse	DIT Social Media for NPD (SPD), Open Design, Circular Economy	• Emerging legibility issues regarding the design from reverse engineering • Difficulty in dealing with patenting in open design and crowdsourcing • Potential disrespect for existing patents in the case of openly shared design • Engaging external individuals could lead to unexpected, unplanned, and rather anarchic behaviors • Require specific expertise in cross-cycle and cross-sector collaboration and especially digital technologies in order to facilitate the transition • Need to build skills in circular design to improve product reuse, remanufacturing, recycling, and cascading in order to be restorative and regenerative by design • Require different design strategies for circularity	S2B1

Stage	***Challenge***	***Concepts***	***Drawbacks***	***Ref***
S3 Open Manufacturing	Assess the product quality & verified quality assurance	DIT Approach, Open Manufacturing	• Uncontrolled manner on how production is controlled • Lack of proper procedures on whether or not the product quality can be assured • Difficulty to assess whether or not the product properly follows the safety regulations • Insufficiently considered customer rights and care in case of product defects	S3B1
	Apply regulations concerning occupational safety in production and product safety	Individualized Production, Democratized Manufacturing	• Lack of overall approach on how safety regulations are applied in the context of distributed local production • Regardless of how the product has been designed or manufactured it must be in line with safety regulations *e.g.* the Machine Directive if manufactured and sold in Europe • Difficulty to assess whether or not working conditions are safe for workers, especially in the case of distributed manufacturing	S3B2
	Ensure the lowest level of product waste	DIT approach, FabLabs, Resource Efficiency	• Increased production waste while prosumers are encouraged to recreate their individualized product • Only part of the 3D printing material is recyclable • Lack of investment on recycled material for feeding 3D printers • Most of the 3D printing material will become waste according to the prototyping effect	S3B3
S6 Green Logistic	Initiate a reverse supply chain approach	DIT approach, supply chain, circular economy	• Lack of reverse logistics allowing the collection of used products • Need more research on how to create value from materials after their use • In several cases reverse supply chains and second-hand markets do not exist yet • Need to re-design supply chains from greenfield for the circular economy to happen	S6B1

Stage	**Challenge**	**Concepts**	**Drawbacks**	**Ref**
S7 Social Reuse	Apply regulations concerning environmental protection and dismantling safety	DIT Sustainability regulation and environmental protection	• Emerging ethical concerns regarding the reuse network and ecosystem • Uncontrolled quality assurance of the recycling process • Unvalidated recycling quality due to difficulties measuring emissions & produced energy • Uncontrolled recycling process and quality due to difficulties sharing assessment resources (equipment, methods and tools) • Unapplied regulations concerning occupational safety in dismantling and recycling due to outsourcing • Unvalidated Machine Directive for safe working conditions for the workers, especially in the case of distributed local recycling	S7B1

S1B1: Franke, Piller, 2004; Aral, Walker, 2011; Zhu et al., 2017; Culnan et al., 2010; Chiu et al., 2012; Roberts et al., 2016.
S2B1: Lanz, Järvenpää, 2019; Lewandowski, 2016; Bressanelli et al., 2017; Bocken et al., 2016; Gaiardelli et al., 2008; Go et al., 2015; Sundin et al., 2009.
S3B1: Lanz, Järvenpää, 2019.
S3B2: Lanz, Järvenpää, 2019.
S3B3: Lanz, Järvenpää, 2019.
S6B1: Bressanelli et al., 2017.
S7B1: Bressanelli et al., 2017; Hirscher et al., 2018.

Identified Co-creation Challenges and XR Implementation Benefits

Regarding the enabling technologies, the analysis of selected articles focuses on immersive technologies, especially XR (Table 6), leaving analysis of the remaining identified enabling technologies like AM, BD, AI and IoT to future work.

It appears, as was the case some decades ago with CAD/CAM technologies facilitating the industrial design of products, that XR technologies greatly facilitate the immersive design of compelling experiences (Pallot, Richir, 2016). However, social immersion and distributed collaboration are emerging trends in the Immersive Virtual Environment (IVE) research context that have actually turned out to be hot research topics toward an Immersive Collaborative Environment (ICE) platform in which all stakeholders can be immersed. Empirical studies on the use of XR technologies have highlighted the positive impact of the use of IVE (VR/AR/MR) for stimulating imagination and creativity (Fleury *et al.*, 2020; Mille *et al.*, 2020; Gorisse *et al.*, 2020) leading to an increase of fluency and originality of produced ideas. Other empirical studies have demonstrated the power of virtual prototyping within the ICE (Pallot *et al.*, 2017; Dupont *et al.*, 2018) and transverse drawbacks like cybersickness phenomena induced by immersive environments, as well as the fact that XR devices currently remain expansive.

Conclusion and Future Work

This study has several limitations inherited from the fact that previous relevant work might have been missed or wrongly discarded. This is due to the subjectivity of the selected articles considered as most relevant through the search keywords. The decision to group the challenges, benefits, and drawbacks within NPD PLC stages is also an arbitrary decision, even if extremely useful for avoiding the duplication of benefits. The identification of the NPD PLC stages is based on previous work; nonetheless, these selected PLC stages are not recognized as a standard among scholars. Despite the fact that we have used many keyword synonyms in the search process, some challenges, benefits, and drawbacks might have been missed as well. Further to this, despite the fact that we started by using an overall Google Scholar search in order to identify the most prolific databases, there might be other databases and potentially relevant articles that we have missed.

Table 6 – **Description of DIT social ideation & co-design stages challenges and XR implementation benefits**

Stage	***Challenge***	***Concepts***	***Benefits***	***Ref***
S1 Social Ideation	Unleash creativity	Inspiration	• Increased creativity by simulating movement in a VR environment • Stimulated creativity through visualizing alternative designs overlapping reality using AR or MR device	S1B1
		Imagination	• Enhanced imagination due to immersion within a purely imaginative virtual world bringing a higher engagement and fun into the activity compared to face-to-face in the real world • Increased fluency (number of ideas generated) and originality of the ideas produced through embodiment into a famous inventor avatar	S1B2
		Sketching	• Increased number of represented ideas within VR freehand, since we know that the "show of hands" is more efficient to find new concepts because this leaves mental space available to focus on generating ideas • Enhanced creativity when someone becomes immersed in VR to sketch ideas compared to paper/pencil design • Increased sketching capacity when someone becomes immersed in VR compared to more traditional computer-based applications using a mouse and a keyboard for interacting with the app	S1B3

Stage	***Challenge***	***Concepts***	***Benefits***	***Ref***
S1 Social Ideation & S2 Co-Design	Ensure mutual understanding and sensemaking	Realistic Avatars	• Increased performance in a collaborative task when participants' avatars are realistic • Enhanced communication among participants when avatars are attractive due to a higher visual and behavioral fidelity, leading to increased performance on a collaborative task • Stimulated exchanges among participants that look at each other's avatar more frequently due to more effective non-verbal communication (*e.g.*, head and hands movements, face expression).	B1
		Content representation modes	• Easier communication and collaboration among participants within different extended reality conditions • More effective communication with the combination of oral and visual modality	B2

Stage	***Challenge***	***Concepts***	***Benefits***	***Ref***
S1 Social Ideation & S2 Co-Design	Ensure mutual understanding and sensemaking	Synchrone *versus* Asynchrone	• Increased ideation and design collaboration effectiveness and efficiency thanks to enhanced mutual understanding and sensemaking through the synchronous immersive collaboration with AR or MR devices as new concepts appear over the existing real environment • Improved mutual understanding and sensemaking through the VR synchronous immersive project stakeholders' collaboration in observing/reviewing and eventually interacting around a 3D twin product • Reinforced sensemaking and shared understanding during an asynchronous immersive review of a 3D twin product for *e.g.* production/assembly/test feasibility analysis	B3
		Symmetric *versus* Asymmetric	• Higher participant satisfaction and sense of presence during an asymmetric collaboration interface with an individual wearing an HMD and other(s) looking at a large immersive screen • Increased accessibility to collaboration through the use of asymmetric visualization technologies with a correct sense of presence despite the difference in technology equipment • More natural and obvious distribution of roles within an asymmetric technological environment	B4

Stage	***Challenge***	***Concepts***	***Benefits***	***Ref***
S2 Co-Design	Improve design choices assessment and validation	Immersive Visualization	• Higher level of object assessment and choice validation with VR drawing tools like Google Tilt Brush due to its immersive visualization feature • Enhanced users' ability to evaluate their initial idea and change their mind after observing their 3D model with different points of view within a VR immersive environment	S2B1
		Spatial Exploration	• Higher degree of novelty and originality of produced ideas due to immersive viewing • Increased ability of users to develop a more global vision of their idea thanks to an immersive visualization compared to CAD tools	S2B2
		Immersion in Models	• Augmenting real size feelings through a virtual full-scale visit allows users to better comprehend the general shape of the explored 3D object compared to a CAD tool • Increased precision in the activity, perception, and better memorization of the viewed models due to the full-scale visit effect of VR tools.	S2B3

S1B1: Fleury et al., 2020
S1B2: Guegan et al., 2016
S1B3: Mille et al., 2020; Gasques et al., 2019; Ibrahim, Rahimian, 2010; Jackson, Keefe, 2016; Yang et al., 2018; Feeman et al., 2018;
B1: Gorisse et al., 2020; Seyama, Nagayama, 2007;
B2: Serras et al., 2020; Pallot et al., 2017; Dupont et al., 2018.
B3: Mille et al., 2020; Eynard et al., 2015; Pallot et al., 2017; Dupont et al., 2018.
B4: Jeong et al., 2020; Eynard et al., 2015; Pallot et al., 2017; Dupont et al., 2018.
S2B1: Lee et al., 2019; Eynard et al., 2015; Pallot et al., 2017; Dupont et al., 2018.
S2B2: Lee et al., 2019; Pallot et al., 2017; Dupont et al., 2018.
S2B3: Calderon-Hernandez, et al., 2019; Eynard et al., 2015; Pallot et al., 2017; Dupont et al., 2018.

This study investigated the challenges, induced potential benefits, and possible drawbacks as well as enabling technologies to implement this renewed DIT approach. Regarding enabling technologies, this study was restricted to the analysis of challenges overcome by XR technologies and their induced benefits, as well as transverse drawbacks at the earlier stages of the NPD PLC. Overall, this study contributes to the required clarification of the DIT approach and implementation. It also contributes to bringing new knowledge to both scholars and practitioners interested in the democratization of innovation, design, and manufacturing as well as individualized products. The results confirm the uniqueness of this DIT approach, which stands at the crossroads of several phenomena, namely: (i) the 4th industrial revolution (I4.0); (ii) the digitization era; (iii) the consumer trend toward individualized products; (iv) the democratization of innovation, design, and manufacturing through the digital economy and its satellites, such as the platform/sharing economy; (v) and the increased citizens' concern on sustainability driving the implementation of the circular economy. They also demonstrate the long list of challenges to be overcome to implement this DIT approach and induced benefits as well as possible drawbacks; though this study has revealed a lack of empirical studies that observe these negative impacts while there is a plethora of observations on positive impacts.

Last but not least, XD technologies appear to be an appropriate enabler of DIT implementation, especially at the ideation and design stages, thanks to the power of virtual prototyping, enabling stakeholders' ability to: (i) quickly reach a mutual understanding of an idea, its related concepts and usage scenario; (ii) anticipate the resulting UX; hence, the ability to deduct the degree of customer satisfaction and a willingness to adopt the represented solution; (iii) acquire the necessary knowledge by quickly learning by doing without any risk; (iv) follow a secured step-by-step process to fulfil a task. Finally, besides a SWOT study on the I4.0 implementation (Calabrese *et al.*, 2020), we did not find any previous study on the identification of challenges, benefits, and drawbacks covering the same spectrum of implementation platform. Therefore, we had to identify and collect these within previous studies from different publication streams such as the more obvious ones within SPD and SM research communities, as well as less obvious ones within NPD and social media intersecting the digital economy, platform/sharing economy and I4.0, as well as immersive technologies.

In terms of drawbacks, besides the fact that there is a scarcity of empirical studies on negative impacts, we found some significant drawbacks such as the lack of suitable customer skills for appropriately contributing to design and manufacturing activities. This could result in imitative and unimaginative solutions, and transverse ones such as peoples' concern about ownership and respect for regulations (Lanz, Järvenpää, 2019). The DIT sustainability, individualization, and democratization approach looks promising for the fashion and furnishing business sectors, especially for fulfilling demand from young digital natives and sustainability-aware customers, as this is currently ongoing in the tourism sector in order to abandon the unsustainable mass tourism approach. In terms of future work, it would make sense to carry out surveys about DIT players' expectations (*e.g.*, manufacturers, makers, designers, interior architects, marketers, consumers, prosumers) whatever the business sector. Such surveys would constitute the second step of a holistic appraisal, as the first step was the literature review that allowed us to identify the most relevant DIT implementation challenges, induced benefits, and drawbacks. Then, based on these two steps, a conceptual framework could be developed in order to obtain a comprehensive picture of DIT implementation, through enabling technologies (XR, BD, AI), including benefits and drawbacks as well as a better understanding of business opportunities and risks. Finally, an analysis of the remaining enabling technologies (AM, BD, AI) needs to be carried out in order to identify their particular induced benefits and drawbacks.

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