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Key Competencies for Circular Manufacturing

Marta Pinzone and Marco Taisch

Politecnico di Milano, Department of Management Engineering, Lambruschini 4b, 20156 Milan, Italy

ABSTRACT

The transition towards circular economy represents a major challenge faced by manufacturing companies and society alike. However, the 'human side' of the circular economy and the role of people-driven factors in the transition have received little attention so far. The present study aims at contributing to fill this gap by outlining key competencies for circular manufacturing identified through a review of the literature and then validated by means of semi-structured interviews with academic and manufacturing experts. In doing so, the study enriches our current knowledge on key competencies for circular manufacturing, which are also useful for practitioners willing to identify the skills required to update or create new job profiles, to assess the competency level of employees and then activate training, counselling and improvement programs to fill relevant gaps.

Keywords: Circular economy, Sustainability, Competency, Competence, Skill, Manufacturing

INTRODUCTION

In recent years, the circular economy has progressively attracted the interest of stakeholders worldwide. Recognizing the fundamental role played by the environment, its functions and interactions with the economic system, policy makers, companies, consumers and research centers have devoted more and more attention to the circular economy as an alternative to the neoclassical, linear economic model (World Manufacturing Foundation, 2021).

With the aim of achieving sustainability, the implementation of closed production and consumption loops (e.g., reduce, reuse, recycle, recover, redesign, remanufacture) have been promoted throughout the manufacturing sector. Several new frameworks and practices have been developed to assist manufacturers and their value networks in the implementation of circular products, processes and business models (Acerbi and Taisch, 2020) to extend the lifespan of products and eliminate waste (Fantini et al., 2015).

However, the transition towards circular manufacturing still presents several challenges (World Manufacturing Foundation, 2021). Among others, the "human side" and the role of people-driven factors have received little attention (Oliveira et al., 2019; Bertassini et al., 2021; Marrucci et al., 2021). Specifically, even though it has highlighted that circular manufacturing requires new skills, a few studies have investigated the needed competencies so far

(e.g., Jabbour et al., 2019; Sumter et al., 2020; Sumter et al., 2021; Schlüter et al., 2022).

To contribute to fill this gap and support interested stakeholders in progressing towards circular manufacturing, the present research study aims to answer the following research question: *"What competencies are needed by industrial companies for the transition to and implementation of circular manufacturing?"*.

RESEARCH DESIGN

To achieve the above-mentioned objective, the research process was organized into two main phases: 1) literature review; 2) expert interviews. The materials and methods applied in each phase are illustrated in the following paragraphs.

Literature Review

The literature review was carried out following the recommendations of the PRISMA 2020 statement. Accordingly, at first the research question addressed by this study was conceived. As reported above, it is: *"What competencies are needed by industrial companies for the transition to and implementation of circular manufacturing?"*

Articles for the review were identified using the Scopus database. The following keyword combination was used in the search for the initial sample of articles: (circular or green), and (manufacturing or industry), and (training or skill* or competenc* or human or HR or people or worker* or operator or profess*). Keywords were searched in articles' abstract, title and keywords. The results of this initial search were refined using three steps: Step 1 – Application of Scopus database filters: articles and reviews as well as conference proceedings written in English and published from 2010 to 2022 were included. Step 2 - Title screening and exclusions of not relevant items. Step 3 - Reading of abstract and full text. Besides, the grey literature was surveyed because of the novelty of the topic (e.g., consultancy reports, practitioner-oriented publications, etc.).

The final sample of articles was read in-depth and analysed. Key competencies were extracted from each study and tabulated in an excel file. Finally, a cross-analysis was carried out to highlight similarities and divergences, eliminate redundant competencies, and group similar competencies in the same cluster.

Expert Interviews

The list of circular competencies extracted from the literature was then validated by means of expert interviews. Semi-Structured interviews were conducted involving experts from academia and manufacturing companies. Specifically, one Italian assistant professor, who is coordinating some EU projects about circular economy in manufacturing, and three CSR/Sustainability Managers of Italian manufacturing companies were contacted and interviewed. Each interview lasted about one hour during which the list of

competencies was presented to the expert and expert's comments about its relevance, clarity and completeness were collected.

RESULTS

Table 1 reports the seventeen key circular manufacturing competencies identified from the literature review and validated by experts. During the interviews, the experts confirmed the relevance of the competencies and applicability in industrial settings. They did not propose any additional competency.

Table 1. Key competencies for circular manufacturing.

COMPETENCY	DESCRIPTION	REFERENCES
Basics of sustainable development and circular economy	Clear understanding of the holistic concept of planetary boundaries, sustainable development, and principles of circular economy.	ANE (2020); Janssens et al. (2021); Sumter et al. (2021); Cabral and Dhar (2019); Bianchi et al. (2022)
Design and management of multiple product-service life cycles	Ability to design product-service systems that have multiple use cycles, to use secondary raw materials, to ensure efficiency in the use of all resources along the lifecycle.	De los Rios and Charnley (2017); Jabbour et al. (2019); Phung (2019); Sumter et al. (2020); ANE (2020); Sumter et al. (2021); Zubir et al. (2021)
Design and management of circular operations and production systems	Ability to develop and operate innovative transformation technologies, circular processes and systems to optimize sustainability impacts.	Jabbour et al. (2019); Janssens et al. (2021); Sumter et al. (2021); Cabral and Dhar (2019); Zubir et al. (2021)
Design and management of circular value chains	Capabilities for planning, setting up and improving industrial symbiosis, integrated reverse logistics and circular value chains	Jabbour et al. (2019); ANE (2020); Zubir et al. (2021); Janssens et al. (2021)
Sustainable Marketing, Re-Marketing and Re-introduction in the market	Ability to plan demand for recovered products on secondary markets, use sustainability-oriented communication strategies, pricing and incentives to engage consumers.	Sumter et al. (2020); Sumter et al. (2021); Janssens et al. (2021)
Assessment of circularity and environmental, social and economic impact	Capability to map, analyze and evaluate the environmental, social and economic impacts of systems across their lifecycles and assessment of circularity levels of business models, processes, products, etc,	Sumter et al. (2020); ANE (2020); Sumter et al. (2021); Janssens et al. (2021)
Circular Value Propositions and Business Models	Capability to develop Circular Business Propositions and Models, to create a vision and engage collaborations through value networks, to implement a roadmap toward the new circular configuration.	Sumter et al. (2020); ANE (2020); Sumter et al. (2021); Janssens et al. (2021)
Analysis of external context, trends and future scenarios	Capability to identify, analyse and anticipate the influence of external factors – such as environmental trends, CE policies and regulations, standards, etc – on the company's present and future scenarios.	Janssens et al. (2021); Bianchi et al. (2022)

Continued.

Table 1. Continued.

COMPETENCY	DESCRIPTION	REFERENCES
Development and use of digital solutions as an enabling factor for the circular economy	Capability to develop and implement innovative solutions based on digital technologies to support the transition to circular manufacturing.	Jabbour et al. (2019); Phung (2019); ANE (2020); Janssens et al. (2021)
System thinking	Being able to approach sustainability from all sides; to consider time, space and context in order to understand how elements interact within and between systems.	ANE (2020); Janssens et al. (2021); Bianchi et al. (2022)
Critical thinking	Being able to assess information and arguments, identify assumptions, challenge the status quo, and reflect on how personal, social and cultural backgrounds influence thinking.	Janssens et al. (2021); Bianchi et al. (2022)
Problem Framing and Solving	Capability to formulate current or potential challenges as a sustainability problem in terms of difficulty, people involved, time and geographical scope, to identify suitable approaches to anticipating and preventing problems, and to mitigating, adapting and solving already existing problems.	ANE (2020); Zubir et al. (2021); Janssens et al. (2021); Bianchi et al. (2022);
Creative thinking	Being able to see situations, objects and problems from another point of view, to give space to one's imagination, make original connections and think outside the box	Janssens et al. (2021); Sumter et al. (2021)
Entrepreneurial mindset	The ability to act on ideas and opportunities and to transform them into values for others	Janssens et al. (2021)
Multidisciplinary Teamwork/Collaboration	Ability of understanding partnerships, enabling new ways of collaboration and dialogue across disciplines.	ANE (2020); Zubir et al. (2021); Sumter et al. (2020); Sumter et al. (2021); Janssens et al. (2021)
Lifelong learning	Being able to learn how to quickly learn things from different and fast evolving thematic areas.	Janssens et al. (2021)
Adaptability	Being able to manage transitions and challenges in complex sustainability situations and make decisions related to the future in the face of uncertainty, ambiguity and risk.	Janssens et al. (2021); Bianchi et al. (2022)

DISCUSSION AND CONCLUSIONS

The present study is one of the first that sheds light on the key competencies required for the transition towards circular manufacturing. It outlines seventeen key competencies for circular manufacturing that should be developed in order to help companies to improve towards more sustainable production and consumption systems.

In doing so, the article provides an answer to the call raised by numerous researchers (e.g., Jabbour et al., 2019) and industrial stakeholders (e.g., ANE, 2020), and it makes a valuable contribution to our current knowledge by

expanding and going beyond the insights provided by previous studies which were mostly focused on design-related skills (e.g., Sumter et al., 2020; Sumter et al., 2021).

The present article makes a valuable contribution to manufacturing practice, too. The circular manufacturing competencies represent a first guidelines that managers can use to identify the skills needed in their companies. They can be used as a simple reference to assess competencies gaps and, thus, create relevant learning and development programs (Pinzone et al., 2016). In addition, the list of competencies can be used to enrich existing job descriptions or create new job profiles. Finally, they can be a support during the recruitment process to easily identify and evaluate the characteristics of candidates to be hired.

The findings of the current research should be interpreted considering the limitations this study has. Researchers interested in circular manufacturing are encouraged to address those limitations in future. First, although the literature review was carried out following the recommendations of the PRIMA statement, some bias may still affect the results obtained. Second, the number of interviews can be increased and diversified to improve the robustness and generalizability of the findings. Third, the list of competencies extracted from the literature could be enriched by means of empirical data from industrial case studies. Finally, adopting a design science approach, researchers could also develop new (digital) artifacts aimed at describing, organizing and assessing relevant competencies. In this respect, defining proficiency levels for each competency and building an ontology of circular manufacturing competencies represent promising avenues for future research.

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