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SHORT COMMUNICATION

Circular Makerspaces as Alternative Employment Platforms for Circular Jobs

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Abstract
Transitioning towards a circular economy requires holistic consideration encompassing environmental, economic, and social dimensions. This perspective paper explores circular makerspaces as innovative platforms for fostering social integration and creating employment opportunities within the circular economy, as makerspaces can offer a more inclusive alternative to traditional employment platforms. They have the potential to unveil unrecognised talents, bridge access to under-utilised human capital, and act as pivotal conduits to a decent and inclusive circular labour force. Drawing insights from the European Horizon 2020 project: Pop-Machina, this perspective paper emphasizes the importance of collaborative efforts among policymakers, practitioners, and researchers to unlock the full transformative potential of circular makerspaces. By prioritizing the social aspect of sustainability and leveraging the network of circular makerspaces, circular makerspaces can unlock unexplored human capital, provide employment opportunities and cultivate inclusive, sustainable communities, while highlighting their potential for societal empowerment and innovation. Finally, this perspective paper underscores the need for ongoing research and collaboration to comprehensively understand and evaluate the role of circular makerspaces in the inclusive circular labour market, ensuring that the social dimension remains central to sustainable development endeavours and informing effective policy making.

Keywords Circular economy · Entrepreneurship/entrepreneurial innovation · Sustainability · Social integration · Marginalised skills · Capacity building

JEL Classification System O13 · P28 · P48 · Q01 · Q56

Introduction

Transitioning to a Circular Economy (CE) is expected to have a net positive effect on employment.[1] According to the International Labour Organization (ILO), the CE could create around 6 million new jobs globally by 2030, with approximately 700,000 of them in the EU [11], [12, 13].

[1] To achieve a sustainable transition towards a CE, one should address not only environmental and economic aspects but also social dimensions, which have recently begun to be explored [1–10]. Within this growing body of literature, employment emerges as one of the most discussed social issues.

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The increase in circular jobs, as defined by Circle Economy [14], is concentrated in occupations that support CE strategies. These new jobs often require technical and manual skills due to more labour-intensive activities,activities such as repairing, remanufacturing, resource sorting, reverse logistics, and recycling [15]. Furthermore, the labour market for the CE is diverse and heterogeneous, requiring various education levels and skill sets [16]. These skills are important components of human capital, which Stahel (2019) defines as "people, their skills and creativity combined with a caring attitude." Human capital is key to equip individuals for circular jobs and thus for the foundations of a sustainable circular society. However, the role of human capital is often overlooked in the CE debate, despite its importance in unlocking the CE's potential [17].

Hence, there is a need for education and training programmes that provide individuals with the necessary technical knowledge and skills for circular jobs and entrepreneurship. Not only there is a necessity for re- and upskilling, but there is a growing need for this education and training programmes to develop new skills for the CE to be inclusive [18]. Research on new circular skill taxonomies (Straub et al., 2023) and projects like CircularSkills [19] highlight this need. Furthermore, Gallardo-Vázquez et al. [20] argue that the CE's emphasis on improving efficiency and resource use can lead to profound social impacts, such as enhanced professional profiles and training focused on people-oriented activities. They also emphasize that barriers to specialised training in human resources can significantly hinder the achievement of these goals. Yet, it remains unclear how the human capital required for these jobs can be developed.

While circular activities are already relevant within European economies, and specific strategies have been put in place, such as the Circular Economy and the Social Economy Action plans [21, 22], their contribution to foster and leverage human capital to meet circular goals is modest, especially considering the critical role they must play in the transition to a CE [23, 24]. As a result, the effect on labour remains limited, and highly capable human capital often goes unrecognised and access to the labour market restricted. In the EU, the labour market of people aged 15 to 74 years accounted for 12.3% of the extended labour force in 2022. This corresponds to 27.5 million people facing an unmet supply of employment [25]. Addressing some of the constraints leading to this under recognition of highly capable human capital, could play a crucial role in accelerating the transition to a CE.

Current educational practices and employment platforms are not yet aligned with CE values, failing to adequately prepare individuals for circular or green jobs [26]. A potential solution lies in Maker Education, which can improve the CE skillset. Additionally, focusing on those who are currently underused in the labour market, such as the unemployed or underemployed, is essential. Many marginalised individuals possess the needed technical and manual skills but face barriers to entering the labour market due to a lack of inclusivity. The Maker Movement can help democratise access to manufacturing tools, making them available to a broader public, including marginalised groups.

This perspective paper presents circular makerspaces (CMS) as alternative employment platforms for circular jobs. CMS are community-led spaces where manual skills and knowledge are shared, fostering environmental, social, and business goals[27].[2] They play a potentially important role in promoting circular literacy, a circular mindset, and inclusive employment opportunities, engaging all individuals, particularly the vulnerable and

[2] The Fab.City most likely refers to makerspaces (more specifically fab labs) in general. The CMS terminology emerged within Pop-Machina experimentation [48]

disadvantaged, in quality, paid work [28]. Many makers are thus engaged in circular production, adopting values-based lifestyle choices.

This perspective paper aims to highlight the potential of CMS as platforms for inclusive employment opportunities, emphasising their role in fostering sustainable communities. Inclusivity here refers to the active engagement of all individuals, regardless of their socio-economic and demographic characteristics, particularly the vulnerable and disadvantaged, in quality, paid work. Due to their collaborative and disruptive nature, CMS offer capacity building and entrepreneurial opportunities through inherent social innovation. These spaces facilitate the exchange of diverse ideas and practices, enabling participants to learn from one another and develop new competencies. CMS also recognise and leverage existing skills (and thus unexploited human capital), allowing individuals to apply their knowledge in new contexts and contribute to community projects. By providing access to shared resources, tools, and expertise, CMS help individuals and groups to experiment with and implement innovative projects. This environment not only fosters personal and professional growth but also stimulates the creation of new business models and ventures that align with CE principles.

Drawing from the European H2020 project Pop-Machina (2019–2023), this perspective paper suggests that CMS can (i) make currently unrecognised skills visible, (ii) provide inclusive access to underrepresented human capital, and (iii) foster circular and social entrepreneurship. The Pop-Machina project supported the CE and collaborative production by establishing CMS and empowering maker communities in creating circular designs. There were 23 partner institutions[3] working in the Project. In each city, Pop-Machina involved up to several hundred practitioners and citizens. One of the objectives was to mobilise citizens under the banner of CE and collaborative production. The key to achieving this objective was to engage existing makers and citizens, who are not makers, as circular makers in the Pop-Machina pilot cities including Leuven (Belgium), Venlo (The Netherlands), Istanbul (Turkey), Santander (Spain), Thessaloniki (Greece), Piraeus (Greece), and Kaunas (Lithuania).

The remainder of the perspective article is structured as follows. First, the authors present the dimensions of a decent and inclusive circular labour market through a focused analysis of the relevant CE literature. Second, the authors elaborate on the role of CMS as employment platforms by reflecting on the results, insights and practices from Pop-Machina project. Finally, the authors discuss how these relate to the framework of socially restorative butterfly for the circular economy [29]. The authors believe that this perspective paper will trigger future discussions on how research, policymakers, and public authorities should leverage CMS as alternative employment platforms, since they can be a bottom-up catalyst for a more inclusive urban transition to a circular economy.

Dimensions of a decent and inclusive circular labour market

While job creation is often emphasized as a benefit of the CE, merely focusing on job creation is not enough. The establishment of decent working conditions and high-quality employment opportunities [30, 31] is key to accelerating the CE transition. This necessitates not only focusing on the quality, safety, and salaries of these circular jobs,[4] but also

[3] Pop-Machina involved more than 100 direct colleagues, among which were about 20 civil servants across seven cities.

[4] Circular jobs, as mentioned in Introduction, are occupations directly or indirectly linked to circular economy strategies. These jobs, primarily in repairing, remanufacturing, recycling, and reverse logistics, tend to be more concentrated in technical-skilled sectors.

extending attention to the well-being and health of those engaged in them [4, 31]. This requires a social revaluation of these jobs. The CE – and consequently the jobs it creates – would benefit if it covers different social needs, as argued by Barford & Ahmad [29] who call for a 'socially restorative CE'.. Valencia et al. [8] identify several key dimensions situating CE initiatives from a socio-economic perspective. These socio-economic dimensions highlight the importance of how people work and collaborate (reorganise), build on existing practices that may not be categorized as CE (remember), and prepare for attitude and behavioural change (rethinking education).

Social inclusion in the labour market is another critical aspect to consider. This entails ensuring equitable opportunities for individuals from various backgrounds, including gender, age, abilities, and ethnicities, to participate in and benefit from CE initiatives. According to the European Commission, labour markets are inclusive, 'when everyone of working age, in particular vulnerable and disadvantaged people, can participate in quality, paid work'.[5] This objective could be advanced through various means, such as facilitating job creation, fostering inclusive entrepreneurship, eliminating barriers to employment, and promoting skills development.[6] This holds particular significance for marginalized and vulnerable demographics, including individuals with disabilities, ethnic minorities, the long-term unemployed, and NEETs (young people Not in Education, Employment, or Training) [32].

Involving local communities in CE decision-making processes and project development, considering their specific needs and concerns, can have beneficial effects on the local economy [33, 34]. It does not only further support inclusion, but also provides a pathway for identifying untapped human capital potential. In the same context, encouraging collaboration between various stakeholders, including public authorities, businesses, NGOs, and educational institutions, can nurture such a labour market.

Finally, entrepreneurship as an initial form of self-employment, has been found to have a positive influence on circularity [35]. Especially with the rise of social and circular entrepreneurship, the upcoming circular labour market is expected to have a rather interesting mix of circular start-ups and scale-ups, with some success stories originating from rather unexpected human capital [16]. Thus, encouraging the development of new ventures within the circular economy, with a focus on inclusivity and supporting entrepreneurship among underrepresented groups, can be an important dimension for the scaling up circular practices within the (evolving) labour market.

Building on the needed dimensions of a decent and inclusive circular labour market in fostering circularity, the following section explores the role of circular makerspaces (CMS) as employment platforms, shedding light on their ability to facilitate collaboration, bridge skill gaps, and empower individuals within the circular economy.

Circular makerspaces as employment platforms

Makerspaces are thriving environments where diverse individuals come together to share knowledge, skills, and innovations. These spaces attract not only leisure-oriented and volunteer participants, but also professionals seeking creative collaboration. For less privileged groups, makerspaces provide a unique opportunity to connect with active individuals

[5] https://ec.europa.eu/social/main.jsp?catId=1134&langId=en
[6] https://ec.europa.eu/social/main.jsp?catId=1134&langId=en

and create networks that can support their integration into the wider community. Furthermore, less privileged individuals often possess valuable practical skills that may not be formally recognised or acknowledged due to the absence of associated diplomas. Makerspaces serve as platforms to showcase and valorise these skills, empowering individuals to embrace and promote their abilities, while making them visible to the local community, recognizing their true value.

Circular makerspaces (CMS), distinct from traditional makerspaces, focus more on circular strategies such as sharing, repairing, and optimising existing resources rather than solely on innovation [36]. They are, by design, key to achieving proper circularity as defined for example in Figge et al., [37]. This emphasis on low-tech solutions and resource optimisation reduces barriers to entry for less privileged individuals, making it easier for them to participate actively. CMS embrace the concept of a *jugaad economy*, wherein frugal and resourceful solutions are employed to address challenges. Within Pop-Machina, beyond their focus on circular strategies, the community itself was one of the drivers in their sustainability, enhancing the human capital potential of the volunteering group and of the city. This was reflected in the citizens' visions of circular makerspaces in Pop-Machina pilot cities; seeing CMS as social, inclusive and supportive places where individuals from diverse groups can share equipment, materials, artefacts and knowledge, they can take care of local problems collectively and contextually, while creating new business opportunities [38].

In the context of a decent and inclusive circular labour market, CMS can be viewed as inclusive informal platforms of employment that facilitate connections between the local community (including less privileged groups) and the active (circular) labour market. By enhancing circular skills, fostering networks and supporting circular entrepreneurship these makerspaces enable unrecognised human capital to gain confidence, visibility, and ultimately access to the labour market.

First, by leveraging the practical skills possessed by less privileged individuals, CMS provide an avenue for their meaningful engagement, contribution and recognition. Even in cases where they are found to be lacking the knowledge or skills, circular makerspaces offer hands-on training and experiential learning, which is usually tailored for circular jobs. The Pop-Machina Maker Academy includes several examples of such trainings, some of which are openly available through the Pop-Machina Open Knowledge Tool.[7] At the early phases of the product, this academy served as a valuable platform for training Pop-Machina makers, who later became actively involved in the creation and management of Pop-Machina CMS. Once Pop-Machina CMS were established, together with other makers at the local and regional level, they helped train citizens as circular makers. Within this scope (i.e. the PMA), Pop Machina CMS conducted a total of 216 learning and training activities touching upon various topics pertaining to circularity and making. Examples include 3D printer days in Leuven (Belgium), recycling plastic workshop with the Precious Plastics methods in Istanbul (Turkey) and Venlo (Netherlands), Business Planning Master Classes in Thessaloniki (Greece), three-wheeler bicycle production workshop in Kaunas (Lithuania), CO2 sensor production workshop in Santander (Spain) and so on. In a way, for underprivileged communities, while Pop-Machina Open Knowledge Tool provides a comprehensive list of courses and training on circular making, (i.e., anyone with an internet connection can access the courses), Pop-Machina CMS provide hands-on experience with circular making (i.e., these spaces are open to anyone in Pop-Machina pilot cities).

Second, adding to the dimensions discussed in the previous section, CMS are often designed to be inclusive due to their open-access nature and community-led use. However,

[7] https://okt.pop-Machina.eu/

there is a lot of debate about whether makerspaces are indeed all-inclusive, with some examples pointing towards the contrary, such as [39] who presented that the maker movement is actually not inclusive to non-dominant communities such as women, people of colour, and people with disabilities, or the work of Marotta, [40] who found that most of the makers actually identify predominantly themselves as white, wealthy, healthy, educated and being men. Still, it is widely agreed that makerspaces do have the capacity to be all-inclusive, if certain biases are properly addressed. Thus, inclusivity in CMS should be treated as a given but should be carefully addressed. Pop-Machina CMS are owned and operated by municipalities. The project showed that the involvement of municipalities in establishing and governing makerspaces could bring benefits for inclusivity. For example, across all pilots, the municipalities' existing links with various NGOs, research institutions, and local networks helped Pop-Machina CMS reach out to less privileged populations easily (e.g., KEDV-Foundation for the Support of Women's Work in Istanbul or AMICA Societies for People with Disabilities in Santander), and allowed conducting circular making activities with them. Such activities mainly had an experimental purpose to foster learning and collaboration (even though sometimes induced by the nature of the project) among the various stakeholders involved in the management of the CMS. Furthermore, the municipal involvement had an indirect positive impact on the inclusivity of Pop-Machina CMS, by providing budget, resources, access to infrastructure, and so on. For instance, Venlo makerspace, supported by the local government, provides essential infrastructure as well as job opportunities for the unemployed people in the neighbourhood. However, it should be noted that the top-down governance structure common in municipalities can challenge the bottom-up operations of CMS, and that municipal involvement in a makerspace could lead to an imbalance in power relations. All in all, discussions around inclusivity of CMS should be not only concentrated on the involvement of less privileged individuals in making activities, but also should consider the makerspace as a holistic place with all the stakeholders constituting its identity.

Third, community engagement and strong ties with the local ecosystem, being industrial, academic, citizens or otherwise, are well established and with notable results. The Pop-Machina Circular Maker Accelerator (PCMA) programme highlighted the extended network that makerspaces have in the local ecosystem. From volunteers to support day-to-day operations to inventors who are called upon to find solutions to industrial challenges, circular makerspaces engage all sorts of makers and stakeholders across the local quintuple helix (i.e., the university-industry-government-public-environment interactions within a knowledge economy), establishing strong collaborations and networks along the way [41]. These networks are often leveraged to informally support employment, by matchmaking market-driven needs to trustworthy human capital from within the local maker ecosystem. Linking industrial, commercial, academic or public stakeholders, CMS are viewed as gateways to employment. CMS role to facilitate connections has become evident, creating even stronger ties among the local communities.

A central aim in the Pop-machina project was to engage citizens in circular making practices (repair, reuse, recycle and so on). In doing so, Pop-Machina makerspaces planned and executed 343 pilot activities with various foci including raising awareness of CE, learning and training in circular making, repair, fabrication, material collection, design, networking, collaboration and dissemination. Almost 30% of these activities (N:103) engaged less privileged groups including 285 isolated people (e.g., immigrants, senior citizens, low-income families), 246 people with special needs (marginalised groups, single parents, people with disabilities), and 171 people who are distant from the labour market (e.g., unemployed, low educated people and illiterate people). As

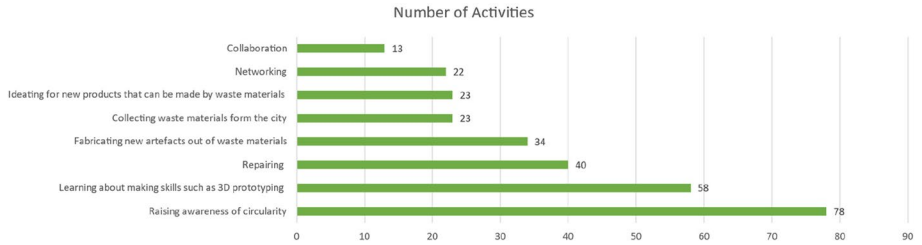

Fig. 1 Overview of activities conducted during the Pop-Machina project and which aligned with making, circularity, and employment skill leverage for the circular transition. Note: The total numbers are higher than the total number of activities reported as there were multiple aims per activity, showcasing the nuanced and interconnected nature of the initiatives

depicted by Fig. 1, these activities mainly involved raising awareness of circularity (78 activities), learning about making skills such as 3D prototyping (58 activities), repairing (40 activities), collecting waste materials form the city (23 activities), ideating for new products that can be made by waste materials (23 activities), and fabricating new artefacts out of waste materials (34 activities), networking (22 activities) and collaboration (13 activities). In a way, Pop-Machina helped underprivileged groups to develop their knowledge and skills in circular making, while helping them expand their networks. While some of these activities were organized within Pop-Machina makerspaces as workshops targeting specific populations (e.g. Young makerslab in Leuven (Belgium) or Fix your bike for dummies event series in Venlo (Netherlands)), others were organized in collaboration with other initiatives (e.g. Istanbul's makerspace's collaboration with Fungistanbul-a music band that produces instruments out of waste material (Turkey) or Kaunas Makerspace workshops co-organized with Kaunas Disability Society (Lithuania)).

Fourth, makerspaces are also known to democratize entrepreneurship [42] besides production. By offering access to infrastructure, equipment, and resources, makerspaces can facilitate the development of circular ventures [43], especially in the context of circular hardware innovation, which is often neglected in incubation and acceleration programmes.

In fact, CMS can catalyse circular entrepreneurship, as observed via the Pop-Machina Circular Maker Accelerator (PCMA) [44]. By offering inclusive business support (i.e., training, mentoring, networking, etc.) to an already highly creative target group (i.e., makers) it is possible to cultivate a circular entrepreneurial mindset that can either lead to new circular ventures or the creation of additional jobs in existing ones. This insight is showcased by Fig. 2 where the results of a satisfaction survey deployed after the delivery of the PCMA showcased that 13% of the respondents (20 makers responded to the survey out of the 105 supported) declared an increase in their personnel, whereas 8% established a second business. Demographics details about the respondents can be found in the caption of Fig. 2.

Business support training and mentoring hold immense value for also cultivating soft skills, that are essential for the labour market, especially considering the skill validation and recognition discussed above.

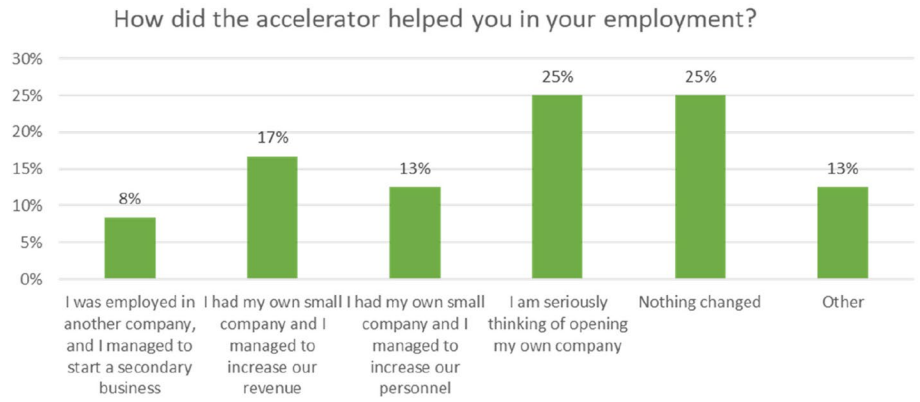

Fig. 2 Results of the satisfaction survey conducted after the Pop-Machina Circular Maker Accelerator. Note: Responses from 20 makers [Demographics: Age range 9(26–35), 5(36–45), 5(46–55), 1(55+), Gender: 11(Female), 6(Male), 3(Prefer not to say), Education: 10 (Master), 8 (Bachelor), 1 (PhD), 1 (High School)]

Discussion

While job creation is often highlighted as a benefit of the CE, there is still insufficient focus on ensuring inclusivity in these employment opportunities, which may not be equally accessible or beneficial to all individuals, particularly those from marginalized or underrepresented groups. The question of who will occupy these new circular jobs deserves more attention, as underuse[8] of human capital remains a concern in the context of in the CE. In this perspective paper the authors elaborate on the potential role of CMS, as alternative employment platforms, in contributing to overcoming these understudied challenges. Beyond the environmental benefits associated to raising awareness about and teaching circular practices, CMS hold the potential for significant social advantages, addressing the often-overlooked social dimension in the CE transition.

Firstly, CMS have the potential to unveil and recognize currently overlooked skills of less privileged groups that could be very valuable in the CE, such as sewing, repairing, upcycling, repurposing, creative problem-solving with limited resources, and other practical skills. By recognizing these skills, CMS address the problem of underutilized human capital, providing opportunities for individuals to contribute meaningfully to the circular economy. This not only enhances their employability and economic inclusion but also enriches the CE with diverse talents and innovative solutions. Simultaneously, these spaces provide them with access to additional skill development and know-how, encompassing a wide range of activities such as using 3D printers, repairing bikes, and crafting instruments

[8] The underuse of human capital refers to the situation where certain skills or talents possessed by individuals are not fully utilized or applied in the workforce. In the context of the circular economy, underuse of human capital can occur when skills that are not traditionally associated with higher education or formal training, such as sewing, repairing, upcycling, and creative problem-solving with limited resources, are undervalued or overlooked in the labour market. This means that individuals possessing these skills may not have the opportunity to fully utilize them in their jobs, leading to their underuse. Recognizing and tapping into these skills within makerspaces can help address this issue by providing avenues for individuals to contribute their skills to the circular economy, thereby maximizing human capital and fostering greater inclusivity in employment opportunities.

from waste materials. In contrast to many paid skills development courses, the activities in CMS are typically offered free of charge and on a recurring basis. This not only eliminates financial barriers but also ensures that less privileged individuals can access continuous skills development opportunities. This enables them to progress in their CE skills at their own pace and in a flexible manner, without feeling undue pressure if immediate success is not achieved.

Second, owing to their open-access nature and community-led use, CMS have the potential to be fully inclusive. Individuals from diverse backgrounds, regardless of socio-economic status, can access and benefit from the resources and knowledge within CMS. This inclusivity fosters a collaborative environment where a wide range of perspectives and skills contribute to sustainable practices and innovation.

Furthermore, CMS can assist (isolated) individuals in expanding their networks and providing opportunities for community engagement. Beyond mere practical skill development, engaging in CMS activities can thus promote social integration, including the enhancement of local language proficiency, which is particularly beneficial for those with a migration background. The network may even evolve into a valuable resource for job opportunities, as it could grant access to connections with stronger ties to the professional job market. This highlights the potential of CMS as a catalyst for social development and pool of professional opportunities.

Finally, CMS are spaces that can democratize and catalyse social and circular entrepreneurship by providing a platform for individuals to transform their innovative ideas into tangible solutions for sustainable consumption, production and maintenance of products. These spaces democratize entrepreneurship by lowering barriers to entry, empowering community-driven initiatives, and fostering a collaborative ecosystem where diverse talents can converge to address societal and environmental challenges. Through this democratization, CMS contribute to a more inclusive and resilient circular economy.

Echoing our introduction, Barford & Ahmad [29] argue that 'for true sustainability and the best version of circularity to be achieved, deeply ingrained social challenges must be resolved'. The authors developed a model for a socially restorative circular economy, covering different social needs that a CE should provide hierarchically, like the Ellen MacArthur 'butterfly'[9] (Bradford and Ahmad, 2021). While the most pressing needs are the inner loops, all loops should be fulfilled to reduce vulnerability and precarity. Although our context is different to theirs – they focus on waste pickers in low and middle income countries—comparing our insights to the model of Barford & Ahmad [29] can still offer a deeper understanding of the potential role of CMS in a socially restorative circular economy.

Based on our preliminary observations, CMS seem especially meaningful in addressing the outer loops of social needs (see the adapted version of the socially restorative CE butterfly in the Fig. 3). The freely available and recurring courses offered at CMS clearly contribute to 'education & skills'. The access to a broader network and enhanced social integration enabled by CMS participation may also empower individuals to amplify their 'voice'—albeit to a certain extent. Moreover, the authors have observed that CMS play an important role in the 'recognition' of already existing skills of less privileged groups. When it comes to facilitating circular making, CMS certainly also provide the necessary 'infrastructure & services' for this. Additionally, participants can enjoy added benefits, such as a comfortable living room experience and access to facilities such as toilets. On the other hand, ensuring the inner loops, such as 'legal rights' and 'fair pay', go beyond

[9] https://www.ellenmacarthurfoundation.org/circular-economy-diagram

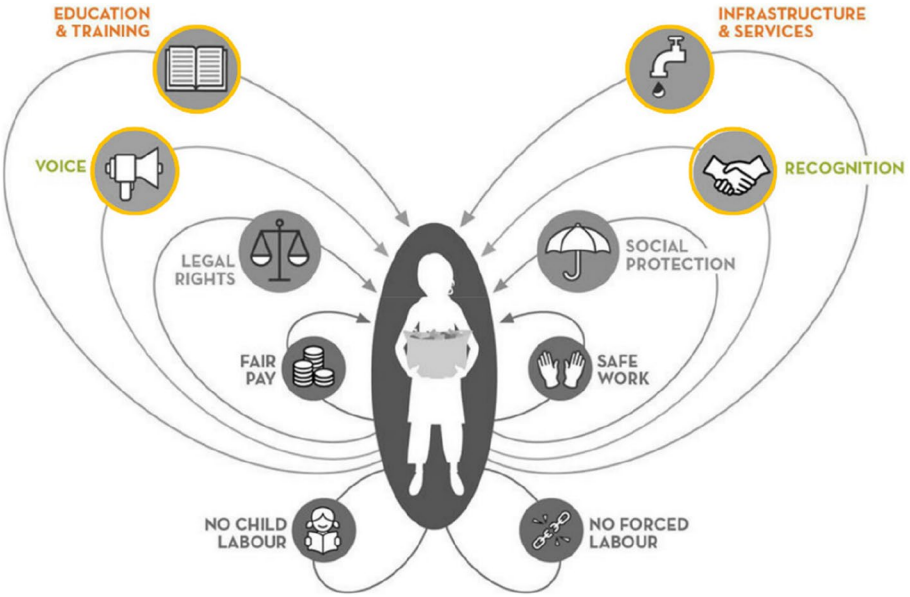

Fig. 3 The role of CMS in social restoration. Note: While this framework has been developed within the scope of a study on waste pickers [29], this approach could be usefully applied to other workers in the circular economy and beyond

the powers of CMS, since this is merely the responsibility of the government and various social partners. Similarly, 'social protection' and 'safe work' require broader societal effort. Nevertheless, CMS could potentially provide some informal 'social protection' through its networks and contribute to 'safe work' locally by introducing a safe working culture. Given that CMS activities are mostly voluntary and community-led, issues like child labour and forced labour appear less applicable in this context. However, it is important to remain vigilant against the potential exploitation of vulnerable groups in the provision of circular maker services without being renumerated.

More indirectly, and through their disruption ideology embedded in their design, CMS challenge the prevailing notions of labour: they offer an alternative vision on what employment means and what work can look like, while accommodating essential care work needed in a CE. Most of the work that occurs in the context of CMS is not formally recognized, yet it remains highly valuable for the community and the CE. The informal, grassroots nature of these efforts can lead to innovations, problem-solving, and community cohesion that may be challenging to replicate in more formal settings. By emphasising informal, community-driven contributions that may not be formally recognized, CMS challenge the conventional understanding of work and could influence a shift towards more flexible and creative forms of work, such as part-time arrangements, freelance work, and informal labour. This informal and innovative work environment within CMS fosters a dynamic approach to labour that may inspire new perspectives on employment in the broader context of the CE.

Simultaneously, CMS hold the capacity to change societal mindsets regarding informal work and the inclusion of less privileged groups. This, in turn, highlights the need for re-evaluating how employment is measured, as current indicators may not accurately reflect the diverse forms of (circular) work. The Pop-Machina Accelerator program uncovered a

mismatch between existing metrics and the actual nature of circular work; while not formally recognized as employment, the work shares similarities with the broader occupational landscape. Addressing this discrepancy, CMS could play a role in developing new indicators that capture the nuanced aspects of employment within their context, thereby enhancing inclusivity for less-privileged segments of society. This shift towards more flexible and creative forms of employment and metrics within CMS not only reflects evolving attitudes towards work but also underscores the potential of informal, grassroots initiatives to drive meaningful contributions to sustainable practices in the CE.

Recent research on the socioeconomic considerations for the CE transition emphasizes the importance for inclusive frameworks. Building upon above insights, the socioeconomic R framework proposed by Valencia et al. (2023) helps to situate the socioeconomic potential of CMS. CMS play a role in reshaping our approaches to work and collaboration, and rethinking care work by providing a dedicated space for such activities in a CE. Furthermore, CMS serve as platforms to rethink and reimagine education through alternative training programs and offering a collective learning environment. Finally, and significantly, CMS serve as sites of remembrance, facilitating the acknowledgement and recentring of skills and practices that may exist but often go unnoticed.

Addressing the social dimension and inclusivity for underserved groups has become a focal point, indicating a gap in current discourse and research. By disseminating these initial observations and insights from Pop-Machina, the authors hope to contribute to further advancing CE research and underscoring the importance of delving deeper into its socioeconomic dimension. While this perspective paper delves into the potential of CMS, a critical gap remains in understanding the *actual* effects of such spaces. Identifying the factors and frameworks necessary for realizing the potential of CMS requires further investigation. A persistent challenge lies in accurately measuring the CMS's effects on employment, as many lack the knowledge and methodologies essential for effective assessment. To address this gap, it is essential to implement metrics and reporting mechanisms. These tools will not only facilitate the evaluation of CMS' contributions to inclusivity in the circular labour market but also provide a means to track progress over time.

Despite the potential of circular making practices for achieving sustainable development goals [45], the adoption of circular business models is still rather slow due to cultural (e.g., operating within a linear business model), market (e.g., price volatility in circular products), regulatory (e.g., lack of synergic government policies), and technological challenges (e.g., missing knowledge of product lifecycle) (Burggraf et al., 2023). New regulations, policies, and legislations are urgently needed to facilitate the adoption of circular business practices (Assman et al., 2023) and to increase the contribution of urban circular economies to sustainable development goals (Puma et al., 2024). Hence, studies focusing on CE and practices that facilitate the adoption of circular business models, such as CMS, should prioritise informing future policies, regulations and legislations in CE to ensure that their potential is fully realised.

Conclusion

One of the socioeconomic advantages of a Circular Economy (CE) transition frequently highlighted in the literature is its potential net increase in jobs. While this beneficial effect of the CE has been extensively discussed, less focus has been placed on addressing where the circular workforce can be sourced or how the necessary skills can be developed.

Achieving a net increase in jobs requires people with skills, creativity and a caring attitude, collectively known as 'human capital', which forms the bedrock of a circular society [17], 2019). However, at present, human capital remains an underused resource, requiring changes in the labour market.

In this perspective paper, it is argued that Circular Makerspaces (CMS) can play a role in fostering the CE by contributing to a more inclusive labour market. CMS can serve as alternative employment platforms facilitating access to existing human capital as well as fostering the development of new human capital. The open and inclusive environment of CMS provides an opportunity to recognise and use previously unrecognised talents. Furthermore, CMS could play a role in nurturing human capital for the CE by providing training opportunities and a collaborative learning space. This occurs concurrently with more social benefits of CMS: their potential for fostering social integration and empowering inclusive communities.

Using the socially restorative CE butterfly diagram by Barford & Ahmad [29] d various elements of CMS that hold particular importance have been identified. CMS facilitate the recognition of skills among less privileged groups, provide infrastructure for the CE and community building, and offer skilled-oriented education and training, all of which are important components of a socially restorative CE. Moreover, the socioeconomic R framework by Valencia et al. [8] helps to highlight CMS potential to reorganise work and collaboration, to rethink care work, to remember existing skills and practices and to rethink education in a CE.

In this perspective paper the authors demonstrated that CMS can open up opportunities for fostering more inclusive and sustainable communities. These insights hold relevance for public authorities seeking to foster inclusivity in the CE transition as well as for other stakeholders wishing to ensure that the CE transition is not only environmentally sustainable, but also socially equitable and accessible for diverse communities. While CMS show promise as platforms for employment opportunities and social integration, further research is needed to fully explore and understand their potential. Policymakers, practitioners, and researchers should collaborate to further harness the transformative power of CMS.

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Data availability The data supporting the findings of this study are publicly available. The data were collected through questionnaires designed to gather feedback during the Pop-Machina project. These data are accessible via Zenodo [46]. The specific number of participants involved in the study can be found either in the open access dataset available on Zenodo or in the "POP-MACHINA Circular Maker Accelerator Handbook" [47], which is available online.

Declarations

Conflict of Interests The authors have no competing interests to declare that are relevant to the content of this article.

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