

Supporting circular economy innovation: An analysis of a circular economy intervention in Wales.

Gary Walpole¹, Peter Treadwell², Laura Steffes¹, Emily Bacon³ and Nick Clifton¹

¹ Cardiff Metropolitan University ²Treadwell Consulting ³Swansea University

Doi: <https://doi.org/10.18573/wer.270>

Accepted: 15/1/2024

Abstract

The Intergovernmental Panel on Climate Change (IPCC) recently advised that “*climate change is a grave and mounting threat to our wellbeing and a healthy planet*” (2023, p.6). This threat underlines the importance of developing businesses innovation capabilities and implementing Circular Economy (CE) principles. Organisations that have developed innovation capabilities are most likely to implement CE principles within their organisations. However, the UK has suffered a ‘long tail of productivity’ largely due to the UK’s relatively low levels of innovation across the firm population. In Wales, the location of this study, output per hour worked was almost 16% below the UK average in 2021, suggesting that the levels of innovation capability might hinder CE implementation. Therefore, evidence on programmes that support organisations to develop their innovation capabilities and their CE understanding should be of interest to policymakers, academics, and practitioners. This paper presents data collected from a university designed CE innovation programme, the Cardiff Circular Economy Network, and suggests that the novel approach adopted enhanced the innovation capabilities and CE knowledge of participants.

Introduction

The recent IPCC report advised: “*climate change is a grave and mounting threat to our wellbeing and a healthy planet*” (2023, p.6) underlining the importance of organisations developing Circular Economy (McArthur, 2015) innovation strategies and operational plans. The Welsh Government has clearly stated its aim of transitioning to a CE within their ‘Beyond Recycling’ strategy (Welsh Government, 2021). Businesses will need to develop their innovation capabilities and understanding of CE to support the stated aims of the Welsh Government and yet most organisations lack a clear understanding of CE principles (Clifton & Walpole, 2023). Organisations that have developed

innovation capabilities are most likely to implement CE principles within their organisations (Goyal et al, 2021). However, the UK has for many years suffered a ‘long tail of productivity’ largely due to the UKs relatively low levels of innovation across the firm population (BEIS, 2021). In Wales, the location of this study, output per hour worked was 15.9% below the UK average in 2021 (Office for National Statistics, 2023) suggesting that the levels of innovation capability are likely to hinder CE implementation. There is a paucity of published literature that focuses on supporting organizations to develop CE understanding and implement of CE principles (Goyal et al, 2021). This paper suggests that policymakers should better understand and promote the most effective approaches and interventions

This work is licensed under the Creative Commons Attribution 4.0 International License.

To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

that support CE implementation to help avert the stark warning from the IPCC (2023).

The Ellen MacArthur Foundation defines the CE as *'an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models'* (Ellen MacArthur, 2013). The numerous academic definitions of the CE have not helped practitioners engage with the concept (Garcia-Barragan, Eyckmans & Rousseau, 2019) despite the theory being promoted as critical to organisational and national economic sustainability. There is a paucity of published academic research, and theory is needed to inform practice (Klein, Ramos & Deutz, 2020). Most papers written on the development of CE capabilities begin by placing it within the teaching of sustainable development and are associated with further and higher education, within schools of engineering, management, and urban geography (González-Domínguez et al., 2020; Sumter et al., 2021).

To address the existing research gap, this paper contributes to literature by outlining a novel approach to developing innovation capabilities and CE understanding. This approach provides reference to underpinning literature as well as presenting empirical data on the efficacy of the intervention evaluated, namely the Cardiff Circular Economy Network (CCEN). Kirchherr and van Santen (2019) called for insights on CE interventions that could begin to address the paucity of CE implementation reports. The paper also answers the call of Franzo et al. (2023) for empirical research that contributes to the understanding of how publicly funded collaborative projects can support businesses to develop innovation capabilities. Therefore, this study offers a contribution by presenting empirical data on the development of CE implementation capability of practitioners. The paper should be of interest to practitioners and policymakers within a region of the UK, Wales,

where a CE transition strategy has been published (Welsh Government, 2021). Moreover, the paper aims to contribute to that reviews the efficacy of approaches to implement CE within organisations (Scalabrino et al. 2022). This study aims to address the following research question: *What pedagogical methods and published theories can be introduced to practitioners to support the development of CE implementation capabilities?*

Literature review

The necessity to transition to a CE is evident, and yet the term remains contested both theoretically and practically. Authors have favoured the above definition of the Ellen MacArthur Foundation (2013). Most CE innovation within organisations has involved establishing 'green' and 'sustainability policies', focusing primarily on the procurement of products that are refurbished or contain recycled materials (Nandi et al., 2020), or the implementation of services with overtly environmental objectives like waste management services or low carbon transport systems (Klein, Ramos and Deutz, 2020). These innovations are important, and local authorities in Wales have performed well in reaching the Welsh Government target of 65% recycling of domestic waste. The Welsh Government 'Beyond Recycling' (2021) strategy states that far more needs to be done to transition to a circular economy. The CE is conceptualised as a series of 'loops' in which smaller loops represent more efficient circulation of resources, recycled and remanufactured materials sit on the outermost loops.

Nandi et al. (2020) described the value of commercial organisations collaborating to implement CE principles; they argue that the waste generated by the health sector during the pandemic has highlighted the need to apply CE principles and practices to medical waste and develop regional supply chains. The post-pandemic economy will require considerable economic impetus, which should

embed CE principles to reduce waste and develop capacity in regional supply chains (Ibn-Mohammed et al. 2020). Ibn-Mohammed et al. (2020) argued considerable investment and thought leadership is required from policy makers to accelerate progress towards a CE through innovation across multiple domains. A recent systematic review by Suchek et al. (2021) emphasised the link between innovation and CE can only be fully established through a multi-level approach where public and private sector actors actively engage; yet nascent engagement with innovation models and methodologies to embed CE requires further practical and theoretical development. Additionally, existing discourse suggests organisations need to become more sustainable in their operations (Gelderman et al. 2017), yet very few studies outline how this can be achieved.

The contemporary literature primarily focuses on how to develop the CE through the teaching of sustainable development principles to students and practitioners. However, contemporary authors argue sustainable development teaching is very unlikely to transform mindsets and achieve CE transition, as this will require different teaching approaches (Kopnina, 2018). The literature suggests that in addition to moving on from *education as usual* and embedding systems and critical thinking, application of new pedagogies should be explored. Lange et al. (2022) in their article *Re-Organise* suggest that prevailing educational taxonomies, such as Bloom's (1956) taxonomy and iterations of this (Krathwol, 2002) may not be sufficient to align with CE learning and development because it lacks a high-level focus on system thinking, self-organisation, emergent and self-directed learning. Lange et al. (2022) argued that CE requires working with a diverse group of people, worldviews, and technologies, and therefore a different taxonomy of learning is required.

All education programmes and interventions are underpinned by theories of learning (pedagogies) to achieve learning outcomes (Wenger, 2000). Research on the application of contemporary pedagogies in teaching CE

suggests systems thinking, critical thinking skills, collaborative problem solving, decision making, and teamwork have all featured in contemporary CE curriculum (Scalabrino et al, 2022). Critical thinking and systems thinking are crucial to transition from unsustainable business models and lifestyles to a functioning circular economy (Kirchherr and Santen, 2019). Scalabrino et al. (2022) highlights the need for critical thinking and disruptive innovation in many global consumer-based and production-focused organisations. Research suggests that 'tier one producers' can influence and encourage transition to a circular economy if they can develop more critical and reflective leadership throughout their organisations to support the transition to a circular economy (Huckle 2012; Kopnina, 2018).

Peer to peer interaction, individual feelings, human values, systems perspectives, and the need for reflective and critical thinking are crucial parts of contemporary CE pedagogy (Walpole et al., 2022; Scalabrino et al., 2022; Bugallo-Rodríguez and Vega-Marcote, 2020; Kopnina, 2018). CE pedagogy needs to offer in-depth CE experiences that stimulate transformative, high level learning experiences (Liu et al, 2022). Scalabrino et al. (2022) suggests pedagogies that engage students in applying models and embed reflective learning are often both inspirational and challenging, as they ask learners to question organisational and personal assumptions as well as existing strategic priorities. Walpole et al (2022) suggest interventions that embed Social Learning theory (Bandura, 1977) and reflective practice (Gibbs, 1988) within a programme that formally creates and supports 'networks of change makers' (Hanna et al., 2018), can bridge the gap between national and regional development, in the form of Communities of Practice (Lave & Wenger, 1991). Programme Communities of Practice (Smith et al, 2018) offer a novel approach for introducing theoretical content and for connecting practitioners with a shared interest (domain) within a community that can share knowledge

and provide a support mechanism for implementation of new services solutions.

Innovation across the private sector is less than ideal and usually on an 'ad-hoc' basis, often in response to regulatory change or demand for new services (BEIS, 2021). The BEIS (2021) report on innovation revealed that only 10% of all businesses are engaged in product and process innovation and unfortunately, businesses in Wales perform less well than their English counterparts. The report asked businesses to rank constraining factors on their innovation activities and identified barriers to innovation. The report highlighted the innovation challenges that businesses face and suggested this 'market failure' presents policy makers in the UK, and in particular Wales, with a productivity challenge as highlighted above (ONS, 2023). The main constraining factors outlined were:

- *Cost factors* (including 'direct innovation cost too high' and 'excessive perceived economic risks').
- *Knowledge factors*; (including 'lack of qualified personnel', 'lack of information on markets' and 'lack of information on technology').
- *Market factors* (including 'market dominated by established businesses' and 'uncertain demand for innovative goods or services').
- *Other factors* (UK Government regulations and EU regulations).

The CCEN programme was designed to mitigate the above outlined innovation barriers in several ways. The project was designed to mitigate cost factors by offering a fully funded programme and signposting businesses to existing support within higher education institutions, Welsh Government and UK Government schemes. The perceived economic risk challenge was mitigated by outlining previous successful projects that demonstrate significant return on investment of time invested. The project mitigated knowledge factors by transferring knowledge from higher education institutions and

facilitating the sharing of knowledge (promising practices) within participants on the programme.

The CCEN programme

The novel CCEN was designed and delivered by Cardiff Metropolitan University to create an inter-organisation Programme Community of Practice (PCoP, Smith et al, 2018) within the Cardiff Council boundary. The programme brought together different businesses and schools within two 'streams' to form a pilot Cardiff Circular Economy Network to facilitate a collaborative regional network, operationalising the conceptual findings of Arundel, Bloch and Ferguson (2019). The programme aimed to create and support 'networks of change makers' (CLES, 2019), to bridge the gap between national and regional development, in the form of Communities of Practice (Lave & Wenger, 1991). CoPs offer an established foundation for connecting practitioners with a shared interest, hitherto primarily used to facilitate knowledge transfer across expert communities which enabled participants to improve their reactions to uncertain and complex situations (Agrifoglio et al., 2021).

The CCEN content combined theory from operations management, product design and organisational development. The programme taught the Design Thinking framework (Lewrick et al, 2020), ordinarily confined to product design programmes, and supports participants to develop their new service solutions (NSSs) through each of the four workshops (see figure 1). CE theory and practice (the Golden Thread) is introduced in the first workshop and threaded through each subsequent workshop for participants to fully understand CE principles. The participants were introduced to reflective practice (Schon, 1983) and encouraged to adopt an iterative approach to their practice and new service solution development. The impact event gave participants the opportunity to capture their learning and learn from other participants within the programme, embedding reflective

practice principles and extending their network to facilitates further boundary spanning activities.

The programme was designed to develop the innovation knowledge and skills of participants by introducing intuitive models that enabled them to produce outputs that would support new service solution (NSS) implementation, outlined in figures 2 and 3. The programme was designed to enhance participants understanding of CE principles and practices through the introduction of case studies accompanied by speakers from the case study organisations. Participants engaged with four workshops over a four-month period.

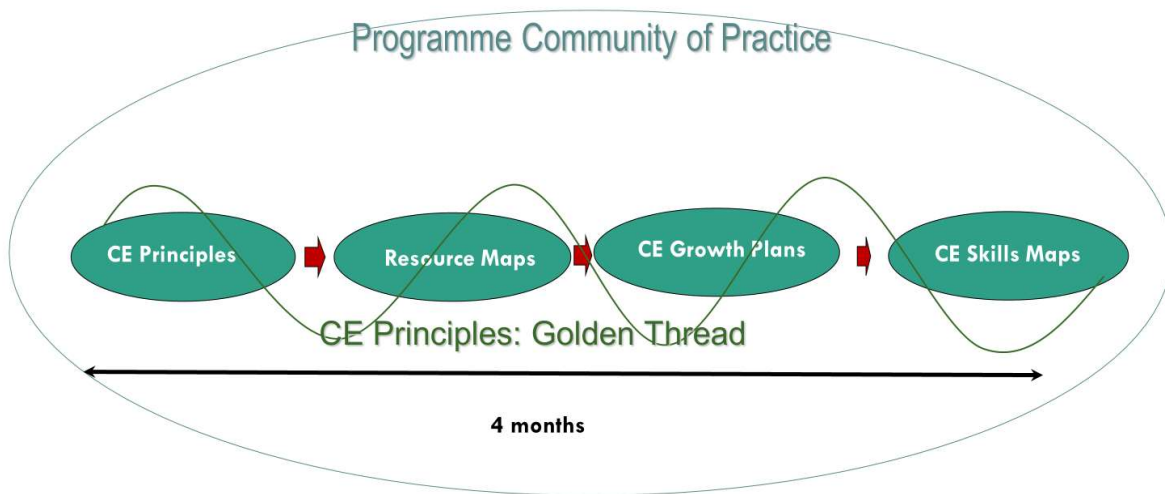
The programme was developed from a critical realist epistemology, which avoided advocating normative models and encouraged participants to adopt an abductive approach to their NSS development (Smith et al, 2018). The CCEN pedagogy was informed by Social Learning theory (Bandura, 1977), and aimed to addresses the 'Knowing Doing Gap' (Pfeffer and Sutton, 1999) practitioners face by supporting participants to produce outputs specific to their context. The participants were introduced to the CoP framework (Wenger & Wenger-Trayner, 2020) and given formal CoP roles to cede agency and to provide the participants with self-governance mechanisms.

The programme delivered an 'Education stream' which involved seventeen teachers from twelve schools in the Cardiff City boundary. The workshops were designed to provide educators with the tools to embed circular economy principles across the curriculum and facilitated the sharing of curriculum resources linked to the CE. The teachers were supported to develop new lesson plans to build CE understanding and practices for their students. This focus contributed to the implementation of the One Planet Cardiff Strategy and educational resources for the new Welsh Curriculum for schools (Welsh Government, 2022). The 'Business stream' workshops engaged thirteen organisations. Six were SMEs, two medium sized businesses and five large businesses from construction, utilities, and financial services. The participants developed new service solutions that would reduce their carbon footprint or enhance biodiversity.

Methodology

To address the research question, a mixed methods methodology was employed. The data was analysed with the theoretical framework of Interpretative Phenomenological Analysis (IPA). Quantitative data was obtained via an online post workshop feedback survey, distributed to programme participants. Whilst there is an inevitable danger in verifying the 'truth' of such virtual feedback to on-line

Figure 1: Cardiff Circular Economy Network conceptual framework



survey questioning, Hookway suggests the replies “*tell us something about the manner in which specific social and cultural ideas are constructed*” (Hookway, 2008, p.78). The study also conducted semi-structured interviews with six programme participants to compile a transcription for thematic analysis. The transcriptions were complemented by short video interviews, captured prior to the ‘impact celebration event’, published on the CCEN website (CCEN, 2022). This research adopted thematic analysis (Flick, Kardoff and Steinke, 2004) to analyse the qualitative data obtained from the semi-structured interviews and video interviews, to develop key themes. The main findings from the workshop feedback surveys and thematic analysis are summarised below. This research assumes successful implementation of CE principles within organisations and the positive themes outlined can act as a proxy for the efficacy of the programme.

Workshop feedback

The aggregated workshop feedback survey data suggests the pedagogical approach of CCEN, which incorporated a programme community of practice approach, enabled participants to effectively develop understanding and implement CE principles. Fifty-eight completed surveys were received and 98% of responses were either satisfied or very satisfied with the workshops overall. Similarly, 98% stated that they felt engaged or very engaged with the interaction and discussion aspects of the workshops. All participants stated that the subject matter of the workshops was important to them on a personal level and 97% stated that the workshop content was relevant to their organisation.

Interview analysis – themes and narratives

The analysis of the semi-structured interview data and video clips revealed key themes and narratives that emerged. The key narratives and themes are outlined below and separated into the themes from the business stream and education stream.

Business Cohort

Business participants reported the value of an opportunity to meet practitioners from different businesses and sectors to share knowledge. The workshops lead to a greater breadth of knowledge due to the different backgrounds of participants and the different perspectives on how to tackle climate change and sustainability issues.

Change of mindset: Participants overwhelmingly agreed that a change of mindset is necessary to tackle climate change and that with a different mindset and perspective, solutions can and will look differently in every industry or business.

“Even as a service industry, there are still plenty of opportunities where we can look to reduce the impact that we have on the environment from the comms that we sent out to our customers to the way that we manage our IT infrastructure and our assets. What I’ve learned is that there is still more that we can do as an organisation, and I found some good things that I can take back and build into some campaigns for promotion and greater awareness among my colleagues.” (Business participant, Service Industry)

Power of collaborative approaches: Business participants realised through the workshops that a systems change is necessary to implement CE solutions. Business participants understood that a systems change is easier to achieve collaboratively as solutions need to tackle the whole supply chain. Networking is an integral part of collaborative approaches, and it was useful for participants to connect with new people who have similar ambitions.

“We understand that the circular economy is not possible by us to deliver by ourselves in isolation. We need to be able to collaborate cause collaboration is a key principle of circularity.” (Business Participant, Construction Industry)

“I think already we’re seeing the networking having some impact. So, we’re getting involved in several external events where we’re talking more about what (the business)

does and how we can impact what the supply chain does through the lending and the funding that we do. So, I think some of the contacts we have especially within the construction industry will help to inform the decisions we make about what projects we fund going forward.” (Business Participant, Service Industry)

Optimisation through circularity: Business participants reported that a change of mindset and a willingness to consider circularity, will present multiple business opportunities. Moreover, they realised that implementing CE principles can lead to more efficiency and greater benefits for stakeholders.

“We own a wide range of properties throughout Wales that support businesses. They occupy the offices and workshops. And what we’re trying to do is to make those offices more energy efficient. So, we’ve installed solar panels. We try and upgrade the buildings so the more energy efficient and more important we try and reduce our cost and pass those benefits on to the tenants.” (Business Participant, Service Industry)

“The actions that I plan to take are around optimisation and the reason I’m saying that is because we are a paperless organisation, and we are doing everything virtually. But now that we’re moving towards hybrid meetings and we are growing, I’ve realised through these workshops that we can do a bit more to save our time and then focus on things that matter most to us, which is working with the client.” (Business Participant, Service Industry)

Figure 2 outlines the outputs from each workshop that participants developed. The programme outputs were taken by participants into their business to form part of their clean growth strategy. The figure also outlines the models and frameworks introduced to participants.

Education Cohort

Greater knowledge and confidence to teach future generations: Education participants reported that they enhanced their CE knowledge greatly and have gained confidence to embed CE across the curriculum. Many education participants have shared their newly gained knowledge with teaching colleagues at their schools. Moreover, education participants understood the relevance of CE to the New Curriculum for Wales and the importance of making future generations aware of CE principles and practices from an early age.

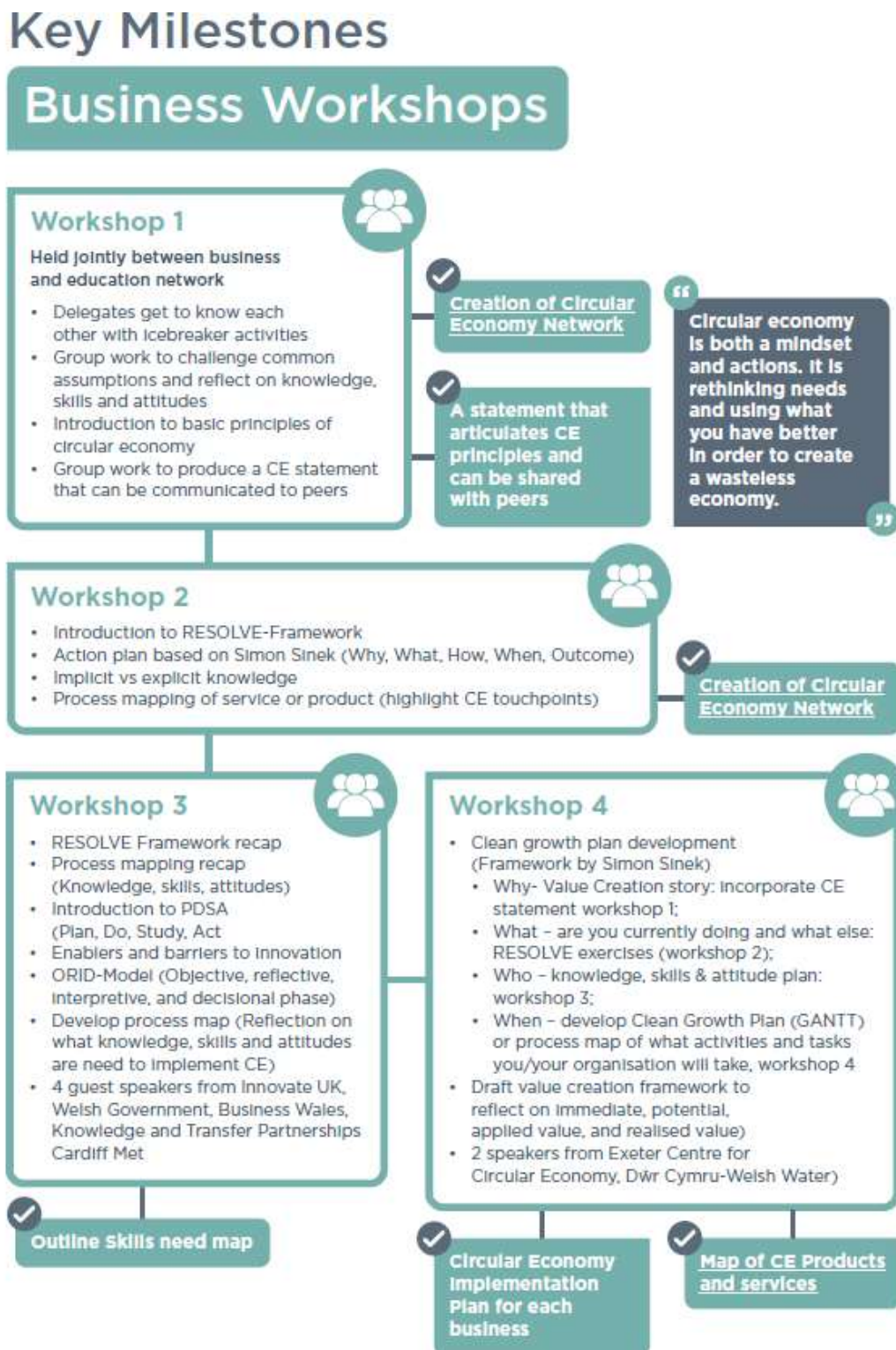
“After the workshops, I went back, and I fed back to all of my colleagues, and we took some time after school to see where it was applicable for us and then to implement some of the circular economy principles into the curriculum.” (Teacher, Primary School)

“It’s really about passing on that knowledge so that the children run with it the rest of their lives and they can build on that throughout their lives.” (Teacher, Primary School)

Seeing the bigger picture and implementing small changes: Education participants explained that the workshops have opened their eyes to the importance of the CE. Especially the knowledge exchange with the business network members has helped them to understand the CE from a systems perspective. Through understanding the bigger picture, participants were able to better understand the impact of minor changes, be it in their personal life or at school.

“For me it’s been more about thinking before acting. So, before you buy things, ask yourself ‘What impact is that going to have if I buy this or should I look for an alternative first?’ and that’s the main one, I’ve taken personally as an individual. As a teaching practitioner, what the workshops have done is put those circular economy principles at the forefront of the mind. So, when we’re planning lessons to think ‘How to put in some circular economy principles in what we’re planning to teach?’” (Teacher, Primary School)

Figure 2: Key Milestones of Business Network



“using reusable veg bags instead of buying a load of potatoes in a plastic bag. Just those simple changes can really make a big difference in the long run, especially if everybody gets on board. As a teacher, really for me, just seeing the difference and then knowing that I can pass that on to my children in class and then as a whole organisation, you know, the little change that we can make and just educating the children on those small changes and how much of a big impact those small changes have.” (Teacher, Primary School)

The key content and milestones for the education cohort follow those in workshops 1 and 2 as shown in Figure 2. Whilst workshops 3 and 4 were focussed on aspects such as the new curriculum for Wales and possible teaching resources.

Common themes were discovered across both the education and business streams. Interviewees suggested that future CE pedagogical programme delivery should incorporate participatory multi-stakeholder collaborations across business sectors, regions and stakeholder groups. The development of programmes and interventions that develop CE capability, like the CCEN programme, should be prioritised to raise awareness of CE principles and to share good practice implementation case studies that could prompt organisations to transition to CE operating models. Interviewees found the employment of experiential and self-directed learning pedagogy within a PCoP fostered the development of post-workshop discussions. The participants suggested, in different ways, the need for clear guidelines from Welsh Government or industry bodies in terms regulatory frameworks and economic incentives to develop and implement CE principles. The respondents also reported that the case studies of CE implementation, introduced on the programme, enabled them to appreciate the value of adopting a ‘storytelling and story-selling’ approach to engaging colleagues with CE innovation. They suggested the local pioneering individuals and organisations, who were described as ‘trailblazers’, should be

supported to scale-up their CE activity. The interviewees suggested CE innovation enablers in ‘anchor institutions’ (large corporates, Universities, Health Boards, Local Authorities and Welsh Government) could better support these trailblazers via public recognition to support the dissemination and promotion of circular innovation interventions.

Discussion

The pedagogical approach of CCEN, locating content within a PCoP (Smith et al, 2018), which adopted social learning principles (Wenger, 2000) supported effective innovation capability development and enhanced CE understanding. The interviewees spoke of an awareness of thinking and acting with a CE approach, which supported the challenge-led approach of the programme. The feedback data supports nascent research that suggests inter-organisational challenge-led programmes that support contextualization of CE solutions are more effective than traditional didactic programmes (Walpole et al, 2022; Liu et al, 2022). The learning mechanisms and processes, including in person and on-line communities of practice participation (Wenger, 2000), peer to peer learning, network attendance, coaching and mentoring which help develop a learning organisational culture (Senge, 1990). These social learning processes, via mutual account giving (Mowles, 2011), enabled high levels of understanding and knowledge sharing. The quantitative data obtained is consistent with the literature as it shows that peer to peer interaction as well as valuing individual feelings are crucial parts of contemporary CE pedagogy, as traditional teaching approaches are unlikely to change mindsets (Walpole et al., 2022; Scalabrino et al., 2022; Bugallo-Rodríguez and Vega-Marcote, 2020; Kopnina, 2018).

Interviewees commented that the proliferation of terms is not helping organisations implement CE, consistent with Kirchherr and Piscicelli’s (2019) findings. This ‘conceptual muddle’ (Kirchherr, Reike and Hekkert, 2017) could be addressed with concerted and consistent messaging from policy makers as suggested by Kirchherr and Piscicelli (2019),

and through interventions that support inter-organisation interaction that develop shared narratives. Many of the participants attempted to build CE awareness into organisational learning, helping embed CE principles and enhancing innovation capability. This reflective commentary highlights the importance of an ‘on-going narrative’ in organisations (Boje, 2008) supporting reflective practice and social learning where the individual and the group develop a shared narrative.

Interviewees described an understanding of their organisation and the CE as a part system, both regional and sectoral (Katz & Khan, 1978). The interviewees described the importance of engaging with local and regional supply chains as well as the imperative of embedding CE principles across the organisation. Kempster and Cope (2010) advised the leadership of SMEs can be idiosyncratic and firm context is an important consideration, suggesting a *“dynamic state between entrepreneur and her or his organisation and the niche market”* (p.32) exists. The data gathered from the CCEN participants supports the assertion that CE principles should be viewed with a systems theory lens. The data also supports the suggestion of Kempster and Cope (2010) that the relationship between the leaders of SMEs and their operating context is dynamic and unique.

Limitations and future research

This paper has drawn on the findings from a small pilot CE innovation programme, hence it is not possible to suggest the findings can be generalised. In addition, the findings are grounded upon an analysis of participants perceptions, which could be judged subjective. Future research could usefully replicate this study at a larger scale across similar

Acknowledgements

This research drew heavily on the commissioned *CCEN Evaluation Report* authored by Dr Peter Treadwell in 2022 (Cardiff Metropolitan University, 2023). Peter passed away in 2022. The authors wish to acknowledge the significant positive impact Peter had on people’s lives. His infectious enthusiasm is sorely missed.

programmes. The data could be augmented with a longitudinal element on implementation of CE principles across the organisations after a six or twelve-month period. The data could be also enhanced by interviewing numerous individuals within each organisation to obtain more reflections on the impact of the programme on the participants and the implementation of CE principles in their organisation.

Conclusions

In the context of the stark warnings of the IPCC (2023), this study provides useful insights on a novel programme that applied contemporary pedagogy to support organisations to develop the innovation capabilities of practitioners to implement CE principles. The academic literature reviewed exposed ambiguity in the understanding of how CE innovation is diffused and how organisations effectively develop CE understanding and implementation capability (Goyal et al, 2021). CE education is often taught within sustainable development programmes and so a wider adoption of CE teaching across all subject areas is likely to broaden understanding and increase implementation. Most existing CE development is designed to develop basic knowledge or enhance knowledge and few interventions develop the skills of practitioners to implement CE principles within their context. Cognitive pedagogies dominate current teaching and yet contemporary literature suggests the transition to a CE will require different pedagogical approaches. Therefore, research that further explores the key learning processes and pedagogies that develop practitioners new service solution development skills would be valuable.

The authors wish to acknowledge the financial support of the Community Renewal Fund and the help of One Planet Cardiff (Cardiff Council) with recruitment and engagement support. The generous financial support of Euroclad Holdings Ltd (Cardiff) enabled the schools to employ supply teachers to release teaching staff to participate in the programme.

References

- Agrifoglio, R., Metallo, C., and Di Nauta, P. (2021). Understanding knowledge management in public organizations through the organizational knowing perspective: A systematic literature review and bibliometric analysis, *Public Organization Review*, 21(1), pp.137–156. <https://doi.org/10.1007/s11115-020-00480-7>
- Arundel, A., Bloch, C., & Ferguson, B. (2019). Advancing innovation in the public sector: Aligning innovation measurement with policy goals. *Research Policy*, 48, 789-798. <https://doi.org/10.1016/j.respol.2018.12.001>
- Bandura, A. (1977) Self-efficacy: Toward a unifying theory of behavioral change, *Psychological Review*, 84(2), 191. [https://doi.org/10.1016/0146-6402\(78\)90002-4](https://doi.org/10.1016/0146-6402(78)90002-4)
- BEIS (2021) *UK Innovation Survey 2021: Report covering the survey period 2018 to 2020*. Available at: https://assets.publishing.service.gov.uk/media/627a3fc68fa8f560b660a590/UK_Innovation_Survey_2021_Report.pdf
- Boje, D. (2008) *Storytelling Organizations*. London: Sage. <https://doi.org/10.4135/9781446214305>
- Bugallo-Rodriguez, A. and Vega-Marcote, P. (2020) Circular Economy, Sustainability and Teacher Training in a Higher Education Institution, *International Journal of Sustainability in Higher Education*, 21(7), pp.1351-1366. <https://doi.org/10.1108/IJSHE-02-2020-0049>
- CCEN (2022) Cardiff Circular Economy Network. Available at: <https://www.walescirculareconomy.com/>
- Cardiff Metropolitan University (2023) Cardiff Circular Economy Network External Evaluation. https://figshare.cardiffmet.ac.uk/articles/online_resource/The_Cardiff_Circular_Economy_Network_CCEN_Evaluation_Report/22310116
- CLES (2019) Community businesses and anchor institutions. Available at: <https://cles.org.uk/wp-content/uploads/2019/02/Community-business-and-anchor-institutions-Digital.pdf>
- Clifton, N. and Walpole, G. (2023). *Future of Innovation Thought Leadership Project – Innovation for a Circular Economy*. *Innovation Caucus*. Available at: <https://innovationcaucus.co.uk/app/uploads/2023/02/IUK-Clifton-final-report-6Feb2023.pdf>
- Ellen MacArthur Foundation (2013) *Towards the circular economy Vol. 1: an economic and business rationale for an accelerated transition (2013)*. Available at: <https://ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an>
- Ellen McArthur Foundation (2015) *Towards a Circular Economy: Business rationale for and accelerated transition*. Available at: <https://ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition>

- Flick, U. Kardoff, E. and Steinke, I. (2004) *A companion to qualitative research*. London: Sage Publications.
- Franzò, S., Landoni, P., Colombo, G., & Verganti, R. (2023). The role of publicly funded collaborative projects in implementing open innovation. *Innovation*, 25(3), 236-256. <https://doi.org/10.1080/14479338.2022.2055040>
- García-Barragán, J. F., Eyckmans, J., & Rousseau, S. (2019). Defining and measuring the circular economy: a mathematical approach. *Ecological economics*, 157, 369-372. <https://doi.org/10.1016/j.ecolecon.2018.12.003>
- Gelderman, C., Semeijn, J., & Vluggen, R. (2017) Development of sustainability in public sector procurement. *Public Money & Management*, 37(6), 435–442. <https://doi.org/10.1080/09540962.2017.1344027>
- Gibbs, G. (1988) *Learning by doing. A guide to teaching and learning methods*. London: Further Education Unit at Oxford Polytechnic.
- González-Domínguez, J., Sánchez-Barroso, G., Zamora-Polo, F., & García-Sanz-Calcedo, J. (2020). Application of circular economy techniques for design and development of products through collaborative project-based learning for industrial engineer teaching, *Sustainability*, 12(11), p. 4368. <https://doi.org/10.3390/su12114368>
- Goyal, S., Chauhan, S., & Mishra, P. (2021). Circular economy research: A bibliometric analysis (2000–2019) and future research insights. *Journal of cleaner production*, 287, 125011. <https://doi.org/10.1016/j.jclepro.2020.125011>
- Hanna, T. M., Guinan, J., and Bilsborough, J. (2018) The 'Preston model' and the modern politics of municipal socialism, *Open Democracy*, 12. Available at: <https://neweconomics.opendemocracy.net/index.html%3Fp=3094.html>
- Hookway, N. (2008). Entering the blogosphere: some strategies for using blogs in social research, *Qualitative Research*, 8, (1), pp91-113. <https://doi.org/10.1177/1468794107085298>
- Huckle, J. (2012). Even more sense and sustainability. *Environmental Education Research*, 18(6), 845-858. <https://doi.org/10.1080/13504622.2012.665851>
- Ibn-Mohammed, T., Mustapha, K. B., Godsell, J., Adamu, Z., Babatunde, K. A., Akintade, D. D., ... & Koh, S. C. L. (2021). A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies. *Resources, Conservation and Recycling*, 164, 105169. <https://doi.org/10.1016/j.resconrec.2020.105169> PMID:32982059 PMCID:PMC7505605
- IPCC (2023) *AR6 Synthesis Report Climate Change 2023*. Available at: <https://www.ipcc.ch/report/ar6/syr/>
- Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, 41(4), 212-218. https://doi.org/10.1207/s15430421tip4104_2
- Katz, D., & Kahn, R. L. (1978). *The social psychology of organizations*. Vol. 2, p. 528. New York: Wiley.
- Kempster, S., & Cope, J. (2010). Learning to lead in the entrepreneurial context. *International Journal of Entrepreneurial Behaviour & Research*, 16(1), 5-34. <https://doi.org/10.1108/13552551011020054>

Kirchherr, J. and Piscicelli, L. (2019). Towards an education for the circular economy (ECE): five teaching principles and a case study, *Resources, Conservation and Recycling*, 150, 104406. <https://doi.org/10.1016/j.resconrec.2019.104406>

Kirchherr, J., Reike, D. and Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions, *Resources, conservation and recycling*, 126, pp.221-232. <https://doi.org/10.1016/j.resconrec.2017.09.005>

Kirchherr, J. W., and van Santen, R. (2019). Research on the circular economy: A critique of the field. *Resources, Conservation and Recycling*, p.151. <https://doi.org/10.1016/j.resconrec.2019.104480>

Klein, N., Ramos, T. B., & Deutz, P. (2020). Circular economy practices and strategies in public sector organizations: An integrative review. *Sustainability*, 12(10), 4181. <https://doi.org/10.3390/su12104181>

Kopnina, H. (2018). Teaching circular economy: Overcoming the challenge of green-washing. in S. Dhiman and J. Marques (eds.) *Handbook of engaged sustainability*. Springer International Publishing AG 2018, pp.1-25. https://doi.org/10.1007/978-3-319-53121-2_48-1

Lange, K. P. H. (2021). Re-Organise - The Game: English - V2.1. *Artefact, Urban Technology / Faculteit Techniek*. Available at: <https://research.hva.nl/en/publications/re-organise-the-game-english-v21>

Lave, J. and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>

Lewrick, M., Link, P., & Leifer, L. (2020). *The design thinking toolbox: A guide to mastering the most popular and valuable innovation methods*. John Wiley & Sons.

Liu, Z., James, S., Walpole, G., & White, G. R. (2022). A communities of practice approach to promoting regional circular economy innovation: evidence from East Wales. *European Planning Studies*, 1-19. <https://doi.org/10.1080/09654313.2022.2132785>

Mowles, C. (2011) *Rethinking Management: Radical Insights from the Complexity Sciences*, London: Routledge.

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2020). Do blockchain and circular economy practices improve post COVID-19 supply chains? A resource-based and resource dependence perspective. *Industrial Management & Data Systems*, 121(2), pp.333–363. <https://doi.org/10.1108/IMDS-09-2020-0560>

Office for National Statistics (2023) *Regional labour productivity, UK: 2021*. Available at: <https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/bulletins/regionallabourproductivityincludingindustrybyregionuk/2021>

Pfeffer, J., & Sutton, R. I. (1999). Knowing 'what' to do is not enough: Turning knowledge into action. *California Management Review*, 42 (1), pp.83-108. <https://doi.org/10.1177/000812569904200101>

Scalabrino, C., Navarrete Salvador, A., and Oliva Martínez, J. M. (2022). A theoretical framework to address education for sustainability for an earlier transition to a just, low carbon and circular economy, *Environmental Education Research*, 28(5), pp.735-766. <https://doi.org/10.1080/13504622.2022.2031899>

- Schon, D.A. (1983) *The reflective practitioner: How professionals think in action*. London: Maurice Temple Smith.
- Senge, P. M. (1990) *The Fifth Discipline: The art and practice of the learning organization*. 2nd edition. New York: Random House Business.
- Smith, S., Kempster, S. and Wenger-Trayner, E. (2018). Developing a Program Community of Practice for Leadership Development, *Journal of Management Education*, 43(1), pp.62-88. <https://doi.org/10.1177/1052562918812143>
- Suchek, N., Fernandes, C. I., Kraus, S., Filser, M., & Sjögrén, H. (2021). Innovation and the circular economy: A systematic literature review. *Business Strategy and the Environment*, 30(8), 3686-3702. <https://doi.org/10.1002/bse.2834>
- Sumter, D., de Koning, J., Bakker, C., & Balkenende, R. (2021). Key competencies for design in a circular economy: Exploring gaps in design knowledge and skills for a circular economy. *Sustainability*, 13(2), 776. <https://doi.org/10.3390/su13020776>
- Walpole, G., Bacon, E., Beverley, K., De Laurentis, C., Renfrew, K., and Rudd, J. (2022) New development: Enhancing regional innovation capabilities through formal public service communities of practice, *Public Money & Management*, 42(8), pp.668-671. <https://doi.org/10.1080/09540962.2021.2021658>
- Welsh Government (2021) *Beyond Recycling – A strategy to make circular economy in Wales a reality*. Available at: <https://www.gov.wales/sites/default/files/publications/2021-03/beyond-recycling-strategy-document.pdf>
- Welsh Government (2022) *A New Curriculum for Wales*. <https://www.gov.wales/curriculum-wales>
- Wenger, E. (2000). Communities of practice and social learning systems, *Organization*, 7 (2), pp. 225–46. <https://doi.org/10.1177/135050840072002>
- Wenger, E., and Wenger-Trayner, B. (2020) *Learning to make a difference: Value creation in social learning spaces*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/9781108677431> PMCID:PMC7495186.