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Exploring Diversity in Engineering & Product Design Education

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University of Bristol

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E&PDE 2026 Foreword

Exploring Diversity in Engineering and Product Design Education

The 28th International Conference on Engineering and Product Design Education (E&PDE) with the theme 'Exploring Diversity in Engineering and Product Design Education' was held at the University of Bristol, on the 3rd and 5th of September 2026. The conference was hosted by the School of Civil, Aerospace and Design Engineering in collaboration with the Engineering Education Research Group. The conference was planned and arranged with the Design Education Special Interest Group (DESIG) of the Design Society, and the Institution of Engineering Designers (IED).

Since its inception in 1999 in the United Kingdom, the E&PDE conference has grown into a leading international forum. Established as a global event in 2004, it alternates annually between the UK and partner institutions abroad. Its mission is to connect educators, researchers, and industry professionals who are passionate about advancing engineering and product design education. The conference provides a platform to exchange expertise, explore contemporary and emerging methodologies, and discuss the evolving relationship between academia, industry, and society.

In 2019, E&PDE introduced visual papers, in which sketched images play the central role in communicating insights, with text providing a supporting function. These contributions continue to expand the conference's knowledge base by capturing ideas in ways that are particularly relevant to design education and research.

Conference theme

Equality, diversity, and inclusion (EDI) are three interconnected concepts that aim to create a fair and welcoming environment for people in education and the workplace. While the gender divide in engineering is acknowledged and faces its own unique challenges to promote gender equality and meet growing industry demand for skilled and professional engineering, according to Represent Recruitment Agency, the design workforce in the UK remains well over three-quarters male. This is substantially higher than the 53% national average. Women are not only likely to be paid worse than male colleagues, but they are also likely to be in less senior positions: with only 17% of design managers who are female. For people who come from Black, Asian or Minority Ethnic (BAME) backgrounds, they make up just 13% of jobs in the industry. BAME staff make up just 12% of senior positions and the pay gap can range up to 17%.

There are also issues around sexuality, especially around what can be perceived as male-dominated, heterosexual professions. LGBTQ+ engineers make up a very small percentage (around 5%) with the design industry doing slightly better (11.7% according to a AIGI census survey from 2019). Nonetheless, there are complex issues around visibility and recognition around sexuality.

While universities are now adapting to accommodate for an increase of neuro-divergent students, and those with learning disabilities, how can engineering and design industries benefit from graduates who see the world differently?

The design industry is also facing demographic challenges, with the vast majority of design professionals in their 20s and 30s. There is a distinct lack of older professional designers.

There are also disparities around socio-economic diversity between engineering and design, with a decline of school age students undertaking Design & Technology (D&T) at GCSE and A-level.

With diversity in a design or engineering team, it can be argued that the result is better products, services, and appropriate solutions. The challenge of this conference is a rally call to ask the difficult questions, acknowledge and address the complex problems and provide solutions that inspire to go beyond characteristics, statistics and data.

The Proceedings

The call for papers invited contributions that:

- explore innovative educational concepts and strategies to prepare students and graduates for future design challenges
- share best practices in transferring knowledge between academia and industry;
- identify and address skills gaps between higher education and professional practice
- provide a platform for diverse voices and perspectives within the design education community.

This year's conference sub-themes included:

- Novel methods for accommodating diversity and inclusivity in multidisciplinary and group-based students' engineering design projects
- Challenges and opportunities for educators to foster an inclusive learning environment for students with diverse needs
- Critique of design methods used in product and service design education
- Fostering EDI through engineering design educational methods
- Educating students in considering equality, diversity and inclusivity in product and service design development
- Integrating the knowledge of diverse designers and cultural nuances in the design phases of products and services
- Innovative approaches promoting EDI principles in engineering and product design education
- Collaborative design education practices fostering the appropriate design of products and services
- Opportunities for AI to enhance diversity in engineering and product design education
- Industry and academia collaborative models for fostering diversity
- Understanding students' experiences from school to higher education, to industry in order to acknowledge and tackle the challenges and barriers faced by designers from minority Ethnic and Heritage communities as well as low socio-economic status

The 2026 conference attracted 132 abstracts, including one visual contribution and 13 student submissions. Following a rigorous double-blind peer review process, 96 papers were selected for inclusion in these proceedings. Over the two-day event,

more than 110 participants from 24 countries engaged in four workshops and 92 paper presentations, creating a vibrant space for exchange and collaboration.

Keynotes

The conference featured two keynote speakers who provided compelling perspectives on diversity within engineering and design industries.

Sunny Panesar, Head of Sales at Ensera Design, shared insights from his career in medical product design consultancy industry and the need to improve diversity in the sector. He provided an overview of the Ethnic Diversity Excellence Program, supported by other UK design consultancies, as well as measures of its success and reflections from his own personal experience.

Laura Tuck, R&D Lead at The Washing Machine Project, spoke about her work in empowering women in off-grid communities using appropriate technology and feedback, as well as her involvement in FemTech product development and advocating inclusive spaces for women.

Acknowledgements

The success of E&PDE 2026 is the result of the dedication of many individuals and organisations. I wish to express my sincere gratitude to the conference co-chairs, Prof Chris McMahon, Dr Thea Morgan, Dr Becky Selwyn and Dr Joel Ross for their support throughout the organisation of the event. Special thanks are also due to Jo Winslow, Ross Brisco, Lyndon Buck, Erik Bohemia, and Francesca Mattoli, for their continued guidance and support.

I am indebted to the members of the international scientific review board for their reviews, which ensured the high quality of the papers presented. Appreciation also goes to Lauren Duvall and Catering and Events team for their organisational support, as well as other professional services staff who contribute tirelessly to the daily workings of the University.

I thank all participants (old and new) for their contributions and engagement. Your commitment, friendship and passion continue to make the E&PDE conference a unique and dynamic forum for advancing engineering and product design education worldwide.

I dedicate this foreword to the late Prof Jason Arday, who took his own life on the 14th of August 2026 after accusations of plagiarism and subjected to relentless public scrutiny by the British media and online platforms; which has deeply shocked the academic community. Prof Arday provided a compelling keynote address at the 2024 Bristol Institute of Teaching and Learning (BILT) 'Voice and Choice-student agency, empowerment and co-creation'. Arday's keynote was titled 'Reasons to be cheerful: is higher education becoming a more inclusive space?' which discussed the continued challenges faced by the sector, with a view to providing a roadmap to future sustained interventions and mobilise greater inclusion and equality. Arday's death is a wake-up call to the higher education sector to re-evaluate how diverse, inclusive and equal they truly are, against what they perceive to be. To fellow academics who have faced unfair discrimination due to age, race, gender, sexuality or religion, we hear you, we see you-and E&PDE will continue to be a welcoming and inclusive space for all.

As a young, black professor with autism, Jason's life story was full of hope and aspiration to anyone who grew up thinking that life in academia was not for them, including myself, which sadly came to a tragic and unjustly end. Rest in Power.

Jeff Barrie

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4th September 2026



Established in 1945, Incorporated by Royal Charter in 2012, the Institution of Engineering Designers is the premier organisation in the UK to represent those working in the many fields of engineering and product design.

Our members enjoy a range of benefits, including mentoring and guidance to professional registration, exclusive access to our job board and newsletters to keep members up to date with relevant developments and events. We host regular events which offer our members the chance to network with other professionals and members receive the Institution's bimonthly journal – Engineering Designer.

We are committed to encouraging CPD for all our members and support ongoing training and skills development.

We offer a wide range of professional registrations: our own register for professional product designers includes the exclusive Chartered Technological Product Designer (CTPD) which is on a par with all other Chartered registrations and exists to provide professional recognition and standing to those suitably qualified and competent persons working in Product Design, with the sister grade of Registered Product Designer (RProdDes) for those not working at Chartered level.

We are licensed by the Engineering Council to assess candidates wishing to join the register of Professional Engineers and Technicians and we also accredit academic and training courses, for registration with either the Institution or with the Engineering Council. Those members who achieve the appropriate academic and competence standards receive Chartered Engineer, Incorporated Engineer or Engineering Technician status.

We are also a licensed body of the Society for the Environment and are able to register suitably qualified and competent members as Chartered Environmentalists (CEnv).

We welcome members from any organisation that has a design function and employs design engineers, and we have many academic teaching staff in membership. To find out more about becoming a member of the IED and a professional registered designer go to www.ied.org.uk



The Design Society is a global community of researchers, educators and practitioners dedicated to advancing the science and practice of design, established in 2000 as a successor to the Workshop Design-Konstruktion (WDK) group 1981. By connecting leading minds across academia and industry, the Society promotes innovation, collaboration and knowledge exchange in engineering design, product development and design research.

Through its internationally recognised conferences, including the flagship International Conference on Engineering Design (ICED), and the Engineering and Product Design Education series (E&PDE) the Society provides a platform for presenting cutting-edge research, sharing best practice, and building lasting professional networks.

Beyond conferences, the Design Society supports a vibrant international research community through Special Interest Groups, publications, doctoral development activities, awards and professional networking opportunities. Whether you are an established researcher, industry professional or emerging scholar, the Design Society offers a forum to collaborate, learn and help shape the future of design.

Why should you engage with the Design Society?

- Connect with a global network of leading researchers, educators and industry professionals working across engineering design, innovation and product development.
- Stay at the forefront of emerging topics including AI in design, sustainability, systems engineering, design methods, creativity and human-centred design.
- Join Special Interest Groups (SIGs) to collaborate with experts who share your research interests and contribute to focused communities within the wider design field.
- Access high-quality research outputs and conference proceedings that showcase the latest developments in design research and practice.
- Develop your professional network through workshops, seminars, conferences and online community activities.
- Support your career development through opportunities aimed at doctoral researchers, early-career academics and established professionals.
- Help shape the future of design research and education by participating in one of the world's most influential engineering design communities.

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DESIGNING REFLECTION: LEARNING ABOUT SUSTAINABILITY IN SMALL CRAFT-BASED DESIGN FIRMS

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ABSTRACT

Small craft-based design firms must address sustainability as a condition for long-term viability, yet training often remains expert-led, prioritising factual knowledge over reflective and organisational learning. This gap is critical in small firms, where tacit knowledge, cross-functional dynamics, and hierarchies shape how sustainability is understood and applied. This study examines how a design-based training programme can foster inclusive organisational learning by activating higher-order and metacognitive processes across roles. Grounded in Anderson and Krathwohl's Taxonomy, it adopts an interventionist single-case study in a small Italian fashion firm. A three-day immersive, screen-free programme used narrative, visual artefacts, and collaborative reflection to support progression toward evaluative and strategic thinking. Qualitative data from observations, external notes, and questionnaires show participants developed analytical, evaluative, and shared strategic intentions. Visual reflection helped surface tacit knowledge and co-create meaning, positioning design-based pedagogy as a driver of collective learning and organisational sense-making and offering a transferable model for engineering and design education, where sustainability learning can move beyond knowledge transmission toward evaluative and metacognitive competences.

Keywords: Design-based capacity building, sustainability competences, industry-academia collaboration, experiential learning, metacognitive reflection

1 INTRODUCTION

Small craft-based design firms are increasingly confronted with sustainability transition as a structural condition of their long-term viability. In these contexts where tacit knowledge and situated expertise are central, transmissive models of training and capacity building risk widening the gap in sustainability learning and everyday practices. If sustainability requires shifts in shared assumptions and interpretative frames, training must foster collective reflection and evaluative agency across roles. Assessment, in this sense, can be reframed as a learner-led reflective practice that surfaces tacit knowledge and supports organisational sense-making. Building on Anderson and Krathwohl's Taxonomy for Learning, Teaching, and Assessing, this study examines how training programmes can activate higher-order and metacognitive processes within a small Italian fashion firm. Through an interventionist single-case study, it explores whether immersive, screen-free, visually mediated reflection can enable cross-functional participants to analyse past actions, evaluate strategic alternatives, and articulate shared sustainability intentions. By designing reflection as a collective practice, the paper contributes to inclusive organisational learning in small craft enterprises.

2 BACKGROUND THEORY

2.1 Inclusive organisational learning for sustainability in small design firms

Design firms face rising environmental, regulatory, economic, and socio-cultural pressures; sustainability is now a structural condition for long-term viability. Yet adoption is often hindered by cognitive and organisational dissonance, creating gaps between commitments and practice [1]. This transition requires shifts in values, assumptions, and interpretative frames that guide decisions and everyday practices; it implies a paradigmatic change to build a sustainability culture in which members

balance economic efficiency, social equity, and environmental responsibility [2]. Sustainability thus lies in shared meanings, not isolated initiatives.

Developing this culture depends on intentional learning processes [3] that go beyond technical knowledge and promote collective critical reflection at the organisational level [4].

Indeed, organisational transformation entails shifts in shared understanding, collective assumptions, and patterns of thinking, which has been described as the “invisible glue” of institutions [5]. Thus, organisational change depends on organisational learning: the acquisition of competence in response to internal or external stimuli, producing lasting changes in collective behaviour and improved effectiveness [6]. This perspective emphasises that learning may involve not only incremental adjustments but also deeper reconsiderations of underlying assumptions [7], [8]. The relevance of organisational learning is particularly pronounced in small- and medium-sized enterprises (SMEs). While SMEs are often key contributors to national economic development [9], they face structural constraints in leveraging internal knowledge and capabilities [10]. These firms rely heavily on the learning capacities of owner-managers and teams. At the same time, they operate in turbulent environments that demand adaptability [11]. The development of effective organisational learning capabilities has therefore been identified as a decisive factor in SMEs' success. In parallel, several authors have highlighted that staff engagement and education are central to developing a sustainability culture [2], [12]. Research within a large multinational company shows that sustainability learning should not be restricted to leaders and senior managers but should be cross-functional and embedded across business functions [13]. To strengthen both knowledge and learners' commitment, it should include technical content and active learning methods [13]. When considering tiny organisations, these principles remain critical, since power dynamics and hierarchies are equally present; inclusion cannot be assumed but must be intentionally designed.

2.2 Limits of traditional *ex-cathedra* training models

Despite the transformative nature of the sustainability transition, training formats in small manufacturing contexts often remain conventional. *Ex-cathedra* models based on presentations, slides, and standardised tests are widely adopted and are oriented toward the transmission and verification of factual knowledge. Such an approach is incoherent with the contemporary constructivist conception of learning [14], and the widely adopted competence-based education, which entails an active, social, and situated process of personal meaning-creation through which learners move beyond the reception of information to develop the holistic competences to address complex, real-world challenges effectively. Within this contemporary framing, the present study focuses exclusively on the knowledge dimension of competence, which can be analytically understood with the support of the *Taxonomy for Learning, Teaching, and Assessing* proposed by Anderson and Krathwohl [3] (Fig. 1). It is a two-dimensional framework that organises learning goals by intersecting: the **cognitive processes dimension**, which contains six increasingly complex cognitive processes: remember, understand, apply, analyse, evaluate, and create; the **knowledge dimension**, which contains a continuum from concrete to abstract of four categories: factual, conceptual, procedural, and metacognitive. The taxonomy provides a detailed framework for intended learning outcomes at the intersection of a specific type of knowledge and the cognitive process required to master it, offering a precise definition that ensures alignment among teaching, learning, and assessment [3]. Traditional *ex-cathedra* approaches primarily activate lower-order cognitive processes (i.e., remembering and understanding) and convey factual or conceptual knowledge. Sustainability competence requires the activation of higher-order processes, including analysing, evaluating, and creating, as well as engagement with the metacognitive knowledge dimension: employees must become acquainted with critically evaluating organisational practices, assessing trade-offs, and envisioning alternative modes of action.

Earlier design-based innovation training, such as the diffusion of design thinking in the 2000s, often showed a knowledge-worker bias, focusing on them (i.e., white-collar) staff and excluding manual or skilled trades workers (i.e., blue-collar) from strategic processes [15]. If sustainability transformation concerns the entire organisation, higher-order thinking must be distributed across roles, requiring inclusive pedagogical models. Reflection is a central mechanism: in SMEs, practitioners can question assumptions in action and reinterpret experience retrospectively. Structured reflection externalises tacit knowledge and transforms it into shared organisational resources, helping to bridge professional cultures. *How can learning experiences be designed to foster shared reflection on sustainability transition across diverse organisational roles within small design firms?* To address this question, a

training intervention was implemented within the *Ecodeck* project (www.ecodeck.polimi.it) in a small Italian fashion company, drawing on Anderson and Krathwohl's Taxonomy to examine the activation of distributed reflective practices.

These insights are relevant to engineering and design education: while Anderson and Krathwohl's taxonomy is already applied to undergraduate (UG) and postgraduate taught (PGT) learning outcomes, sustainability teaching often remains limited to lower-order processes and specialist cohorts, reflecting a knowledge-worker bias. The immersive, design-based approach offers a transferable model for higher education that integrates reflection, narrative, and cross-functional dialogue. It encourages alignment between learning outcomes and pedagogy, and the inclusion of reflective, learner-led assessment alongside standard evaluation.



Figure 1. Revised Bloom's Taxonomy adapted from Heer, R. (2012) Iowa State University Center for Excellence in Learning and Teaching. Licensed under CC BY-NC-SA 3.0.

3 METHOD: INTERVENTIONIST SINGLE CASE STUDY

This research uses an interventionist single-case study, where the researcher acts as a change agent, supporting organisational transformation while observing it [16]. This approach suits real-life contexts, such as activating reflective practices in a small Italian fashion firm, where pedagogy and organisational sense-making intersect. Given the complexity of linking professional cultures for sustainability, a single case offers a holistic view without fragmenting data. Using a training programme as the case, the study frames reflection within action-based research, drawing on Anderson and Krathwohl's taxonomy to generate grounded insights. This enables analysis of how tacit knowledge becomes shared organisational resources in a small firm. Data were collected during testing in fall 2025 with a company of about 20 employees and five participants. Methods included observations by facilitators and external observers, plus daily open questionnaires on sustainability meanings and actions. Results are based on qualitative interpretation of these sources. Data analysis followed a deductive thematic approach: notes and questionnaires were coded against nine Intended Learning Outcomes (ILOs) from the taxonomy, linking reflections to cognitive processes and knowledge dimensions. Two researchers coded a subset independently and resolved differences through discussion. A key limitation is potential bias, as researchers were also designers and facilitators; external observers provided a partial check on these interpretations.

4 CASE STUDY: TRAINING PROGRAMME IMPLEMENTATION

4.1 Setting the learning goals: the intended learning outcomes

The training activities were designed to be delivered across three training days. In terms of the Intended Learning Outcomes (ILOs) related to knowledge about sustainability, the activities were developed using a progressive logic within the Anderson and Krathwohl taxonomy (Tab. 1).

Table 1. Outline of the ILOs analysed through Anderson and Krathwohl's Taxonomy

Training Day		Intended Learning Outcomes (ILOs) Analysis			
ID	Title	ID	Extended ILOs	Cognitive Process Dim.	Knowledge Dim.
1	Understanding individual sustainability competences and values	1.1	Classify sustainability actions, competences, and values according to the provided frameworks.	Understand	Conceptual
		1.2	Predict how personal sustainability competences influence the impact of individual actions in organisations.	Understand	Metacognitive
		1.3	Examine one's own sustainability values in relation to actions undertaken to face everyday sustainability challenges.	Analyse	Metacognitive
2	Analysing values and organisational actions	2.1	Distinguish past organisational actions for sustainability.	Analyse	Factual/ Conceptual
		2.2	Break down past sustainability actions by analysing when, why, what changed, and resulting impacts.	Analyse	Procedural/ Metacognitive
		2.3	Reflect on the evolution of sustainability actions, the cognition of sustainability challenges, and the values that these actions entail.	Evaluate	Metacognitive
3	Evaluating and prioritising strategies for transition	3.1	Classify alternative organisational strategies to address sustainability challenges.	Understand	Procedural/ Conceptual
		3.2	Select the most promising sustainability strategies to be implemented in one's own organisation.	Evaluate	Procedural/ Conceptual
		3.3	Reflect on the organisation's sustainability intention to inform the organisation's transition.	Evaluate	Metacognitive

4.2 Designing the learning experience: an immersive and screen-free approach

The training programme adopted an immersive, screen-free approach to foster engagement throughout the learning journey. Rather than relying on traditional ex-cathedra formats, participants were positioned as active protagonists within a narrative experience. At the core was a speculative storytelling framework inviting them to imagine entering an alternative world where sustainability operates under different rules. In contrast to their “world of origin,” where sustainability is perceived as a cost or constraint, this world framed it as an accelerator of innovation and a strategic lever. To deepen immersion, each day included carefully designed check-in and check-out rituals. Participants crossed a symbolic door, received a personalised “pass”, and engaged in short reflection activities. The physical environment supported this, reinforcing continuity between sessions. The programme privileged hands-on, low-tech interaction. Paper-based tools, value cards, templates, markers, and co-creation canvases stimulated discussion and collective sense-making. The deliberate absence of screens encouraged active participation and creativity, strengthening the collaborative and embodied nature of the learning process.

4.3 Detailing the instructional design: The learning activities and contents

4.3.1 DAY 1: Understanding sustainability values and systems

Day 1 included two main activities centred on individual sustainability competences and actions. The first activity aimed to raise awareness of the environmental, social, and economic dimensions of sustainability. Through a narrative simulation based on real organisational dilemmas, participants engaged with an AI-generated scenario, selected relevant competencies from a shared framework, and collaboratively identified potential sustainability actions informed by each competence. Iterative rounds of listening, reflection, and mapping fostered understanding of how competencies shape individuals' actions within an organisational context. The second activity focused on making participants' sustainability values explicit and prioritised. Using canvas and card-based tools, they mapped actions onto sustainability value areas, reflected on their behaviours, and built a shared value constellation. This process highlighted convergences, divergences, and tensions across environmental, social, and economic dimensions. At the end of the day, participants received an investigation kit (i.e., instructions, canvases to be filled) and were invited to collect evidence of sustainable change in their company for the next session.

4.3.2 DAY 2 – Analysing values and organisational actions

Day 2 included two collaborative activities focused on sustainability actions, competences, and values at the organisational level. In the first activity, participants mapped and critically examined their company's past sustainability-related actions, starting from real change stories. Actions were formalised and organised across temporal, environmental, and social dimensions, allowing the group to visualise patterns, gaps, and systemic effects. Working in pairs and plenary, they developed a shared analytical representation of the organisation's sustainability trajectory and reflected on its complexity. The second activity built on this mapping to examine the sustainability values underpinning organisational behaviours. Using a predefined set of value cards, participants associated values with the mapped actions and constructed a visual value constellation, making alignments and inconsistencies explicit. A closing reflection reconnected values, competences, and actions, and introduced an observation kit for investigating external organisations' sustainability actions before the next session.

4.3.3 DAY 3 – Evaluating and prioritising strategies for transition

Day 3 included two activities focused on sustainability strategies and the organisation's future positioning. Participants shifted focus beyond their own company to explore sustainability transformations in other organisations. They presented cases analysed with the kit through immersive role-play, enabling comparison of change trajectories. Participants then linked them to sustainable development clusters and examined strategies using furniture and fashion case sheets. The activity concluded with a facilitated discussion in which participants identified the priority strategies most relevant to their future development. The second activity used a forward-looking synthesis process to consolidate learning and define a shared strategic commitment. Introduced through the narrative metaphor of the "Sextant," participants revisited the organisation's past and present actions, values, and insights. They then adopted a future-oriented perspective, identifying sustainability challenges and selecting strategic directions aligned with the earlier clusters. The session culminated in the co-creation of a manifesto-style commitment statement and the selection of a limited set of guiding values.

4.4 Discussing the results: The assessment

Across the training, researchers observed that participants consistently engaged in reflective and analytical discussions, demonstrating progression toward the intended learning outcomes (ILOs). During the early sessions, participants demonstrated a solid conceptual understanding of sustainability competences, values, and actions, correctly classifying elements within the provided frameworks and even suggesting actions beyond the initial dilemmas (ILO 1.1). They predicted how their personal sustainability competences could influence the impact of individual actions in the organisation (ILO 1.2) and reflected on their own sustainability values in relation to everyday work practices (ILO 1.3). Researchers noted moments of metacognitive awareness, for example, when participants expressed surprise at recognising non-obvious values such as "Democracy, nonviolence, and peace," signalling a shift from recognition to reflection on prior assumptions. During mapping exercises, participants distinguished and deconstructed past organisational sustainability actions (ILO 2.1), analysing when, why, and what changes occurred, as well as the relationships that enabled them (ILO 2.2). They began connecting values to concrete actions: for example, interpreting "reduction of working hours" as socially driven and "water-based adhesives" as environmentally driven, demonstrating early evaluative sense-making (ILO 2.3). Reflections occasionally extended beyond the workplace, indicating the emergence of metacognitive internalisation. In later sessions, participants actively engaged with external cases and classified alternative organisational strategies (ILO 3.1). They discussed how these strategies were relevant or transferable to their own context, weighing options, and prioritising potential directions (ILO 3.2). In the final synthesis activity, in which participants collectively formulated a strategic commitment and translated it into a visual narrative, researchers observed negotiation, the articulation of assumptions, and shared reflection on future sustainability intentions, confirming achievement of ILO 3.3. Participants remained motivated and curious, demonstrating commitment to applying learning beyond the training. Overall, observations across all days suggest that participants progressed from conceptual recognition of sustainability competences and actions to reflective evaluation and strategic planning, fulfilling the training's ILOs across conceptual, procedural, and metacognitive dimensions.

5 CONCLUSIONS

This exploratory study shows how sustainability training in SMEs can be designed to activate higher-order and metacognitive processes across roles. Grounded in sustainability culture and organisational learning, and structured through Anderson and Krathwohl's taxonomy, the intervention demonstrates how visually mediated reflection can support a shift from conceptual understanding to shared evaluative agency. Learner-led reflection was key in surfacing tacit knowledge and enabling collective sense-making. The findings also inform engineering and design education. The taxonomy-based, reflective approach offers a transferable model for UG and PGT sustainability modules, supporting the development of evaluative and metacognitive competences beyond knowledge transmission.

However, the study involved a single small firm and a limited group, restricting generalisability and capturing only short-term effects. While learning outcomes were achieved, longer-term behavioural and organisational change remains uncertain. Future research should adopt longitudinal approaches across diverse SMEs to assess sustained impact.

REFERENCES

- [1] Bianchi G., Pisiotis U. and Cabrera Giraldez M. GreenComp The European sustainability competence framework. *European*, vol. 30955, pp. 1–40, 2022.
- [2] Bertels S., Papania L. and Papania D. Embedding sustainability in organisational culture – A Systematic Review of the Body of Knowledge, p. 25, 2010.
- [3] Davis K. and Boulet M. Transformations? Skilled Change Agents Influencing Organisational Sustainability Culture. *Australian Journal of Environmental Education*, vol. 32, no. 1, pp. 109–123, Mar. 2016.
- [4] Anderson L. W. and Krathwohl D. R. A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition. Addison Wesley Longman, Inc., 2001.
- [5] Schein E. H. Organisational Culture and Leadership. 1985, Rochester, NY: 1496184. Accessed: Oct. 26, 2023. [Online]. Available: <https://papers.ssrn.com/abstract=1496184>.
- [6] Spicer D. P. and Sadler-Smith E. Organisational Learning in Smaller Manufacturing Firms. *International Small Business Journal: Researching Entrepreneurship*, vol. 24, no. 2, pp. 133–158, Apr. 2006.
- [7] Argyris C. and Schön D. A. Organisational learning: A theory of action perspective. *Reis*, no. 77/78, pp. 345–348, 1997.
- [8] Senge P. M. Mental models. *Planning Review*, vol. 20, no. 2, pp. 4–44, 1992.
- [9] Storey D. J., Keasey K., Watson R. and Wynarczyk P. The performance of small firms: profits, jobs and failures. Routledge, 2016.
- [10] Bell J., Crick D. and Young S. Small firm internationalisation and business strategy: an exploratory study of 'knowledge-intensive' and 'traditional' manufacturing firms in the UK. *International Small Business Journal: Researching Entrepreneurship*, vol. 22, no. 1, pp. 23–56, 2004.
- [11] Wyer P. and Mason J. An organisational learning perspective to enhancing understanding of people management in small businesses. *International Journal of Entrepreneurial Behaviour & Research*, vol. 4, no. 2, pp. 112–128, 1998.
- [12] Benn S., Dunphy D. and Griffiths A. Enabling Change for Corporate Sustainability: An Integrated Perspective. *Australasian Journal of Environmental Management*, vol. 13, Sep. 2006.
- [13] Haugh H. M. and Talwar A. How Do Corporations Embed Sustainability Across the Organisation? *Academy of Management Learning & Education*, vol. 9, no. 3, pp. 384–396, 2010.
- [14] Vrasidas C. Constructivism versus objectivism: Implications for interaction, course design, and evaluation in distance education. *International Journal of Educational Telecommunications*, vol. 6, no. 4, pp. 339–362, 2000.
- [15] Saari T. and Koivunen T. Tacit knowledge in blue-collar work: how workers use it to fulfil their side of the psychological contract. *International Journal of Organisational Analysis*, vol. 30, no. 7, pp. 173–183, 2022.
- [16] Martinsuo M. and Huemann M. Designing case study research. *International Journal of Project Management*, vol. 39, no. 5, pp. 417–421, Jul. 2021.