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Professional learning communities for sustainable education in the 21st century: A systematic review

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Abstract

Even with growing recognition of the need for sustainability within education, there is a dearth of understanding regarding how PLCs, collaborative groups of educators focused on continuous improvement, can systematically contribute to sustainable education. This study explores PLCs as catalysts for incorporating principles of sustainability into 21st century education. A search of databases including ERIC, Education Source, Web of Science, Scopus and Google Scholar was performed for publications between 2000-2024. Selection criteria focused on studies with an explicit focus on PLCs and sustainability or environmental education, yielding 47 peer-reviewed empirical and theoretical sources. Thematic synthesis involved open, axial and selective coding to identify common themes. Findings suggest that effective PLCs help to build capacity for teaching and learning principles of sustainability, environmental literacy and systems thinking among participants. Sustainability-focused PLCs positively impact student engagement, critical thinking and environmental awareness. Common characteristics of effective PLCs include shared vision, collaborative culture, collective inquiry and continuous improvement cycles. Implementation challenges are identified, as are recommendations including policy creation prioritizing time for PLCs, establishing competency standards, funding for PLC facilitation and conducting longitudinal studies into student sustainability outcomes. This review offers evidence-based recommendations to educational leaders considering collaborative approaches to address global sustainability priorities.

Key terms: Professional learning communities, Sustainable education, Collaborative culture, Systematic review

1. INTRODUCTION

1.1 Background and Global Context

The 21st century faces unprecedented sustainability challenges including climate change, biodiversity loss, resource depletion and social inequities which threaten the environmental well-being of future generations (UNESCO, 2017; IPCC, 2021). Education has been identified as a critical instrument for addressing these challenges, with the United Nations Sustainable Development Goals (SDGs), particularly SDG 4.7, calling for all learners to acquire knowledge and skills needed to promote sustainable development by 2030 (United Nations, 2015). Education for Sustainable Development (ESD) has emerged as a pedagogical approach integrating environmental, social and economic dimensions of sustainability into teaching and learning (Sterling, 2001; Wals, 2011).

However, translating the sustainability goals into meaningful classroom practice remains a daunting challenge. Despite policy commitments, many educators lack the knowledge, skills and confidence needed to effectively teach concepts of sustainability (Evans et al., 2017; Zachariou & Kadji-Beltran, 2009). Traditional top-down professional development approaches have proven insufficient for developing the complex competencies required for sustainability education, including systems thinking, anticipatory thinking, critical reflection and collaborative problem-solving (Rieckmann, 2018; Wiek et al., 2011).

Professional Learning Communities (PLCs) offer a promising alternative approach. PLCs are collaborative groups of educators who meet regularly to examine their practice, analyze student learning and engage in continuous improvement through collective inquiry (DuFour et al., 2016; Hord, 1997). Research shows PLCs' effectiveness in improving teaching quality, student achievement and school culture across diverse contexts (Vescio et al., 2008; Bolam et al., 2005; Stoll et al., 2006). Yet despite a growing body of literature on both PLCs and sustainability education, a critical research gap persists: no systematic synthesis has examined the specific mechanisms, characteristics and outcomes associated with PLCs designed explicitly to advance sustainability education. This gap is consequential — without such evidence, educational leaders lack guidance on how to structure collaborative professional learning to effectively meet SDG targets and ESD imperatives.

1.2 Statement of the Problem

The gap between sustainability education aspirations and implementation reflects several interrelated challenges. First, sustainability education requires pedagogical transformation beyond traditional content delivery toward interdisciplinary and inquiry-based approaches that develop critical thinking and action competence (Wals & Benavot, 2017). Seond, educators need ongoing, collaborative learning opportunities to develop refined understandings of complex sustainability issues and effective pedagogical strategies (Evans et al., 2017; McKeown & Hopkins, 2007). Third, sustainability initiatives often remain isolated rather than becoming institutionalized within school culture and practice (Henderson & Tilbury, 2004).

Traditional professional development, characterized by isolated workshops and expert-driven transmission models, has proven ineffective for addressing these challenges (Darling-Hammond et al., 2017; Kennedy, 2016). Sustainability education demands sustained, collaborative professional learning that enables educators to critically examine assumptions, experiment with innovative practices and collectively construct knowledge about teaching for sustainability (Lotz-Sisitka et al., 2015; Vare & Scott, 2007).

The magnitude of this problem is empirically documented: UNESCO (2017) reports that fewer than 40% of countries have fully integrated ESD into teacher training frameworks, while Evans et al. (2017) found the

majority of surveyed teachers in developed nations feel under-prepared to teach sustainability content. Wals and Benavot (2017) similarly found significant gaps between national ESD policy commitments and actual classroom implementation across 193 UNESCO member states. PLCs ideally align with these requirements, offering structures for sustained collaborative inquiry, shared leadership and continuous improvement (DuFour et al., 2016; Stoll et al., 2006). However, empirical evidence examining PLCs' specific role in advancing sustainability education is disjointed across disciplines and geographical contexts.

1.3 Purpose and Research Questions

This study examines how Professional Learning Communities function as facilitators for incorporating principles of sustainability into 21st-century education. The research addresses critical questions:

1. What are the characteristics of PLCs that effectively advance sustainability education practices?
2. How do sustainability-focused PLCs enhance educator knowledge, skills and pedagogical practices related to environmental literacy and systems thinking?
3. What impacts do PLCs have on student learning outcomes related to sustainability competencies?
4. What implementation barriers and facilitators emerge when establishing sustainability-focused PLCs?
5. What policy and practice recommendations support effective integration of PLCs and sustainability education?

1.4 Significance of the Study

This study makes several important contributions. First, it bridges professional learning communities and sustainability education, providing cohesive frameworks for educational improvement. Second, it synthesizes global research across diverse contexts, identifying both universal principles and context-specific considerations. Third, it offers evidence-based guidance for educational leaders, policymakers, and practitioners seeking to leverage collaborative professional learning to address sustainability challenges. Lastly, this study identifies critical gaps requiring further research and innovation.

2. THEORETICAL FRAMEWORK

2.1 Professional Learning Communities

The concept of Professional Learning Communities has grown considerably since its introduction. Hord (1997) identified five attributes characterizing effective PLCs: supportive and shared leadership, collective creativity, shared values and vision, supportive conditions and shared personal practice. This foundational framework emphasized collaborative culture and continuous improvement as essential for enhancing educator effectiveness.

Fig. 1 Hord's five attributes of effective PLCs

DuFour et al (2016) expanded PLC theory by articulating three "big ideas" central to effective PLCs: ensuring that students learn, building a culture of collaboration and focusing on results. They argued that PLCs must function around four critical questions: What do we want students to learn? How will we know when they have learned it? How will we respond when students don't learn? How will we extend learning for students who have demonstrated proficiency? This results-oriented approach positions PLCs as tools for collective responsibility for student learning rather than merely sites for teacher collaboration. Stoll et al (2006) contributed additional theoretical depth by distinguishing between "groups" and "communities," arguing that genuine PLCs are characterized by shared values and vision, collective responsibility,

reflective professional inquiry, collaboration focused on learning and promotion of both group and individual learning. Their work emphasized that PLCs represent cultural transformation rather than structural addition to schools.

2.2 Education for Sustainable Development (ESD)

Education for Sustainable Development arose from the environmental education movement but expanded to include social justice, economic equity and cultural diversity alongside ecological concerns (Sterling, 2001; UNESCO, 2017). The Brundtland Commission's (1987) definition of sustainable development provided foundational principles that educational approaches have sought to operationalize. UNESCO's (2017) framework for ESD identifies five priority action areas: advancing policy, transforming learning and training environments, building capacities of educators, empowering and mobilizing youth and accelerating sustainable solutions at the local level.

Sterling (2001) argued that genuine sustainability education requires paradigmatic shifts in educational purposes, processes and structures rather than merely adding environmental topics to existing curricula. Wals (2011) emphasized that ESD should cultivate "sustainability competencies" including systems thinking, anticipatory thinking, normative competence, strategic competence and interpersonal competence. These complex capabilities require pedagogical approaches emphasizing critical inquiry, collaborative problem-solving, and action-oriented learning rather than the transmission of predetermined content.

2.3 Key Sustainability Competencies

Wiek et al (2011) synthesized research to identify five key sustainability competencies that educational programs should develop:

1. Systems thinking competence: Understanding complex relationships, feedback loops and cascading effects across environmental, social, and economic domains
2. Anticipatory competence: Analyzing and evaluating future scenarios and their implications
3. Normative competence: Reflecting on and navigating sustainability values, principles and goals
4. Strategic competence: Designing and implementing interventions, transitions and transformative governance strategies
5. Interpersonal competence: Collaborating, participating and learning with diverse stakeholders

Rieckmann (2018) expanded this framework to include other competencies relevant for educators: critical thinking, self-awareness, integrated problem-solving competence and cooperation competence. These competencies cannot be developed through traditional didactic instruction but require experiential, collaborative and reflective learning processes, specifically the conditions PLCs can provide for educators.

2.4 Integrating PLCs and Sustainability Education

PLCs and sustainability education reveal substantial alignment. Both emphasize collaborative inquiry, critical reflection, systems thinking and continuous improvement (DuFour et al., 2016; Wals, 2011). The two require cultural transformation rather than superficial programmatic additions (Stoll et al., 2006; Sterling, 2001). Both position learning as socially constructed through dialogue and shared inquiry rather than individually acquired through transmission (Wenger, 1998; Lotz-Sisitka et al., 2015).

However, integration is not automatic. Henderson and Tilbury (2004) noted that whole-school approaches are essential for sustainability education to move beyond marginal "green" initiatives toward systemic

transformation. PLCs offer mechanisms for such whole-school approaches by providing structures through which educators collectively develop sustainability competencies, critically examine pedagogical practices, design an integrated curriculum and collaboratively assess student learning (Evans et al., 2017). PLCs provide organizational structures and collaborative processes through which sustainability education can move from an aspirational goal to embedded practice.

3. METHODOLOGY

3.1 Research Design

This study employed systematic review methodology with thematic synthesis to examine how Professional Learning Communities advance sustainability education in 21st-century schools. Systematic review provides rigorous, transparent approaches to synthesizing research evidence across diverse studies, contexts and methodologies (Gough et al., 2012). Thematic synthesis enables identification of patterns, themes and relationships within qualitative and mixed-methods research (Thomas & Harden, 2008).

3.2 Data collection

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency and replicability (Moher et al., 2009). Comprehensive literature searches were conducted across multiple electronic databases including ERIC, Education Source, Web of Science, Scopus, Google Scholar and specialized sustainability education databases, covering the period 2000–2024. Search strings combined controlled vocabulary and free-text terms, including: ("professional learning community" OR "teacher learning community" OR "PLC") and ("sustainable education" OR "education for sustainable development" OR "ESD" OR "environmental education" OR "green school"). Boolean operators were used to combine terms across title, abstract and keyword fields. Inclusion criteria comprised: (1) peer-reviewed empirical studies or systematic theoretical frameworks; (2) explicit focus on PLCs or equivalent collaborative teacher learning structures; (3) direct relevance to sustainability, environmental or ESD-related educational outcomes; and (4) published in English between 2000 and 2024. Exclusion criteria included: grey literature without peer review, studies examining PLCs without any sustainability focus and articles inaccessible in full text. The search yielded 312 initial records. After removal of duplicates (n = 64), title and abstract screening (n = 248) excluded 178 irrelevant studies. Full-text review of 70 remaining articles excluded a further 23 for not meeting inclusion criteria, resulting in a final sample of 47 studies included in the synthesis.

3.3 Three-Stage Coding Process

Analysis followed Strauss and Corbin's (1998) grounded theory approach employing three progressive coding stages:

Open Coding: Line-by-line examination of texts identified initial codes capturing concepts related to PLC characteristics, sustainability education practices, implementation processes, barriers, facilitators and outcomes. This inductive phase remained close to the data, preserving nuance and complexity (Charmaz, 2006).

Axial Coding: Initial codes were organized into themes representing relationships between concepts. This phase examined conditions, contexts, strategies and consequences, establishing connections between

PLC features and sustainability education outcomes (Strauss & Corbin, 1998). Constant comparative analysis identified patterns across different studies, contexts and educational levels.

Selective Coding : The final analytical stage integrated themes into core categories representing major dimensions of PLC-sustainability integration: essential PLC characteristics for sustainability education, educator capacity development processes, student learning outcomes, implementation strategies, barriers and challenges and policy, and institutional supports. Relationships between categories were mapped into comprehensive conceptual frameworks (Corbin & Strauss, 2008).

3.4 Quality Appraisal

Study quality was evaluated using adapted frameworks from Gough and colleagues (2012) across four dimensions: (1) methodological rigor - including appropriateness of design, sampling adequacy, data collection transparency and analytical coherence; (2) conceptual clarity - clarity of theoretical framing and alignment between research questions and findings; (3) contextual description - sufficiency of contextual detail to assess transferability; and (4) transparency of analytical processes - explicitness about how interpretations were reached. Each study was rated as high, moderate or low quality on each dimension using a structured appraisal template. Studies rated consistently low across dimensions were excluded from synthesis; those rated low on some dimensions were included but flagged as providing weaker evidence, and their findings were weighted accordingly. This differentiated weighting approach enabled the synthesis to reflect both breadth of evidence and its relative strength, consistent with best practice in qualitative systematic reviews (Thomas & Harden, 2008).

4. FINDINGS

4.1 Essential Characteristics of Sustainability-Focused PLCs

The synthesis identified seven interconnected characteristics distinguishing effective sustainability-focused PLCs from generic collaborative groups.

4.1.1 Shared Vision Grounded in Sustainability Principles

Effective sustainability PLCs establish clear shared visions incorporating sustainability values, goals and principles (Ferreira et al., 2007; Reunamo & Pipere, 2011). This goes beyond vague commitments to "environmental education" toward an articulated understanding of sustainable development's environmental, social and economic dimensions and education's role in fostering sustainability (Sterling, 2001).

Research from Swedish schools demonstrated that PLCs explicitly discussing and defining their sustainability vision developed more coherent, integrated approaches than groups with assumed but unexamined commitments (Björneloo, 2007). The process of collectively constructing shared vision itself became a learning opportunity, requiring educators to examine their assumptions, values and beliefs about sustainability, education and their professional responsibilities (Borg et al., 2012).

4.1.2 Collaborative Culture of Inquiry and Experimentation

Sustainability-focused PLCs cultivate cultures where collaborative inquiry, critical reflection and pedagogical experimentation are normalized and valued (Evans et al., 2017; Littledyke, 2008). This contrasts with cultures of isolated practice or mere cooperation around logistical matters.

Critical to effective collaboration is creating safe spaces for examining failures, sharing doubts and taking pedagogical risks (Schnack, 2000; Jensen & Schnack, 2006). German research on whole-school

sustainability initiatives found that PLCs explicitly normalizing experimentation and learning from setbacks produced more innovative pedagogical approaches than those emphasizing only successful practices (Rode & Michelsen, 2008).

4.1.3 Systems Thinking Orientation

Effective sustainability PLCs develop collective capacity for understanding interconnections, feedback loops and unintended consequences across environmental, social and economic domains (Colucci-Gray et al., 2006; Kemmis et al., 2014). Scottish research revealed how PLCs using systems mapping tools to analyze sustainability issues collaboratively developed a more sophisticated understanding of complexity than educators working individually (Colucci-Gray et al., 2013). The collaborative construction of systems diagrams made thinking visible, enabling collective refinement of understanding and identification of leverage points for educational intervention.

4.1.4 Action Orientation and Practice-Based Learning

Sustainability-focused PLCs balance reflection with action, emphasizing practice-based learning through cycles of planning, implementation, observation and reflection (Hofman & Schnack, 2003; Mogensen & Schnack, 2010). This action-oriented approach aligns with sustainability education's emphasis on developing action competence.

Danish research on action competence approaches showed that PLCs organizing their work around action cycles developed deeper pedagogical understanding than groups focused primarily on theoretical discussions (Jensen & Schnack, 2006; Mogensen & Schnack, 2010). Canadian studies examining place-based sustainability education found that PLCs engaging in community-based action research alongside students developed richer understanding of local sustainability issues and more authentic pedagogical approaches (Hursh & Henderson, 2011; Wals & Corcoran, 2012).

4.1.5 Student Learning Focus

Consistent with general PLC principles, effective sustainability PLCs maintain focus on student learning outcomes rather than solely on teacher practice (DuFour et al., 2016; Eames et al., 2006). This includes examining student work, assessing sustainability competencies and using evidence to inform pedagogical refinement.

Research from New Zealand's "Learning to Make a Difference" initiative demonstrated that PLCs systematically collecting and analyzing evidence of student sustainability learning developed more sophisticated understanding of effective ESD pedagogy than groups relying on intuition (Bolstad et al., 2004; Eames et al., 2006). Japanese studies of Environmental Education Teacher Communities found that PLCs using student learning evidence to drive their inquiry cycles produced measurably greater gains in student environmental knowledge, attitudes and behaviors than traditional professional development approaches (Nomura & Abe, 2010).

4.1.6 External Partnership and Community Engagement

Sustainability-focused PLCs often extend beyond school boundaries, engaging with community organizations, environmental groups, local government, businesses and universities (Ferreira et al., 2009; Wals & Corcoran, 2012). These partnerships provide access to expertise, resources, authentic learning contexts and community action opportunities.

Australian research on sustainable schools programs documented that PLCs with strong external partnerships developed more robust sustainability initiatives, accessed greater resources and created

more authentic learning experiences for students than isolated school-based groups (Ferreira et al., 2007; Henderson & Tilbury, 2004). Dutch studies examining regional sustainability networks found that PLCs connected across schools developed collective capacity more rapidly through cross-institutional learning and avoided "reinventing the wheel" (Wals et al., 2008; Wals & Van der Leij, 2007).

4.1.7 Leadership Distribution and Teacher Agency

Effective sustainability PLCs are characterized by distributed leadership where authority, initiative and decision-making are shared rather than concentrated in formal leadership positions (Ferreira et al., 2009; Björneloo, 2007). This distributed model fosters the educators' sense of capacity and responsibility for advancing sustainability education. Swedish research found that PLCs with distributed leadership structures exhibited greater innovation, sustainability and resilience than those dependent on individual champions (Björneloo, 2007; Borg et al., 2012). When leadership was distributed, departure of key individuals did not disrupt initiatives.

4.2 Development of Educator Capacity

The synthesis identified multiple dimensions of educator capacity enhanced through participation in sustainability-focused PLCs.

4.2.1 Professional Learning Communities

Professional Learning Communities (PLCs) are collaborative learning cultures of teachers which provide the necessary conditions for developing sustainable education practices in schools.

4.2.1.1 Teacher-related Outcomes and Impacts

Sustainability Knowledge and Environmental Literacy

PLCs enable teachers to collaboratively develop their understanding of sustainability concepts and issues and their inter-relations with social, economic and environmental aspects (Evans et al., 2017; McKeown & Hopkins, 2007). In particular, studies carried out across a number of developing countries identified that PLCs provided valuable opportunities for teachers to pool their knowledge and practices, learn from each other and engage with external expertise through community partnerships, particularly where formal education on sustainability was not available to teachers (Lotz-Sisitka et al., 2015; Ofei-Manu & Didham, 2018).

Pedagogical Knowledge for Sustainability Education

PLCs contribute to the development of teachers' pedagogical content knowledge for sustainability education, enabling them to acquire an in-depth understanding of how to teach sustainability concepts and build sustainability competencies (Evans et al., 2017; Summers et al., 2000). In particular, UK studies indicate that teachers engaged in PLCs were able to transform their pedagogical practices to include more student-centered, inquiry-based approaches which were more appropriate to the goals of Education for Sustainable Development than the transmission approaches used previously (Littledyke, 2008; Summers et al., 2000). Through collaborative planning, peer observations and reflective discussions, teachers were able to discuss and refine their own pedagogical approaches.

Systems Thinking Competence

PLCs that are focused on building systems thinking amongst teachers support educators in their understanding of the nature of complex systems, how these systems operate, how these systems relate to each other and how they might be changed (Colucci-Gray et al., 2013; Kemmis et al., 2014). Scottish studies that used a pre-post intervention design identified significant improvements in systems thinking competence of teachers participating in PLCs compared to control groups (Colucci-Gray et al., 2013). In particular, collaborative analysis of complex sustainability issues contributed to the development of systems thinking competence at a level that could not be achieved through individual learning.

Critical Reflection and Values Awareness

Values clarification is a key component of education for sustainable development which requires educators to reflect critically on their own values and attitudes and how these might influence their teaching practices and students' learning (Sterling, 2001; Wals, 2011). PLCs provide the collaborative context needed to carry out such critical reflection (Borg et al., 2012; Pipere & Micule, 2014). In particular, Nordic studies identified that through reflective practices carried out within PLCs, teachers were supported to critically evaluate their own worldviews and assumptions in relation to consumption, development, technology and nature which informed their teaching practices (Borg et al., 2012; Reunamo & Pipere, 2011). This critical reflection on values was considered to enable teachers to support their students' own critical reflection on their worldviews.

Collaborative Curriculum Design Capacity

PLCs support teachers in building collaborative curriculum design competencies and capabilities enabling them to co-create innovative approaches towards sustainability education, which is fit for purpose and context appropriate (Ferreira et al., 2009; Eames et al., 2006). In particular, studies conducted across a number of countries that had implemented integrated approaches to sustainability education identified that collaborative approaches taken by PLCs supported educators to design curricula with a higher degree of authenticity, contextualisation and alignment to the goals of sustainability education (Wals & Corcoran, 2012; Lotz-Sisitka et al., 2015).

Confidence and Self-efficacy

PLCs build the confidence and self-efficacy of teachers in their capacity to teach sustainability education and develop the related competencies amongst their students (Evans et al., 2017; Zachariou & Kadji-Beltran, 2009). In particular, Greek studies identified that teachers who participated in PLCs had significantly higher levels of confidence and self-efficacy in relation to teaching environmental education (Zachariou & Kadji-Beltran, 2009). Teachers identified that confidence was enhanced through the collaboration with peers, sharing of practices and responsibilities which reduced anxiety in relation to teaching environmental education.

4.2.1.2 Student-related outcomes and impacts

Environmental Knowledge and Literacy

A number of studies identify benefits to student-related outcomes and impacts of teachers' participation in PLCs on sustainability education. In particular, Greek studies identify that students who were taught by teachers that participated in environmental education PLCs had significantly increased levels of environmental knowledge, understanding of environmental issues and were more aware of human-environment relations compared to control groups (Zachariou & Kadji-Beltran, 2009). Japanese studies on long-term environmental education initiatives that utilised PLCs for teacher professional development

also identified that students who were taught through these initiatives displayed increased levels of environmental literacy across a range of ages from elementary to high-school (Nomura & Abe, 2010).

Critical Thinking and Systems Thinking

Students who are taught by teachers who participate in PLCs on sustainability education receive enhanced opportunities to develop their critical thinking and systems thinking competencies (Colucci-Gray et al., 2013; Eames et al., 2006). In particular, Scottish studies that assessed students' systems thinking capability identified that students whose teachers participated in systems-thinking-focused PLCs had significantly increased capacity for identifying interconnections, feedback loops and system characteristics compared to control groups (Colucci-Gray et al., 2013).

Environmental Attitudes and Values

Studies on sustainability education PLCs identify that students' environmental attitudes, values and worldviews can be positively influenced through teachers' participation in these communities of practice (Zachariou & Kadji-Beltran, 2009; Borg et al., 2012). In particular, Greek studies identified that compared to control groups, students taught by teachers participating in PLCs had more positive environmental attitudes, including increased concern for environmental problems and stronger environmental values (Zachariou & Kadji-Beltran, 2009).

Engagement and Motivation

Studies on PLCs for sustainability education identify that student engagement and motivation can be positively influenced through teachers' participation in these professional learning communities (Ferreira et al., 2009; Evans et al., 2017). In particular, UK studies identified that initiatives that utilised PLCs for teacher professional development enabled students to undertake highly motivating projects on sustainability issues (Littledyke, 2008).

Action Competence and Civic Engagement

Students who are taught by teachers participating in PLCs on sustainability education are more likely to demonstrate increased action competence and civic engagement (Mogensen & Schnack, 2010; Jensen & Schnack, 2006). A number of studies across different contexts identified that through the implementation of projects on sustainability education, students demonstrated increased capacity to take action on relevant issues for their community and wider environment (Ferreira et al., 2009; Bolstad et al., 2004).

4.2.1.3 Implementation Strategies and Success Factors

Strong Leadership Commitment

Implementation of PLCs for sustainability education requires strong leadership commitment to the process (Ferreira et al., 2007; Björneloo, 2007). In particular, leaders need to take active roles in PLCs' governance, provide the required resources, protect PLCs' time from competing school demands and model the leadership behaviors needed to foster a school-level culture of sustainability.

International studies of PLCs for sustainability education identified that it was particularly important that leadership remained committed to the process, especially during the initial stages before sustainability education initiatives started to become established (Rauch & Steiner, 2013; Pipere & Micule, 2014).

Protected Time and Structural Support

To be effective, PLCs need time to be embedded in the school structure, rather than relying on teachers' voluntary time outside their already busy schedules (DuFour et al., 2016; Evans et al., 2017). Schools that have successfully implemented PLCs for sustainability education identify that it is crucial to dedicate protected time within the school schedule to the work of the PLCs (Evans et al., 2017; Lotz-Sisitka et al., 2015). European studies identified that the provision of time for PLCs contributed to increased teacher participation and engagement as compared to other organizational approaches where time was not formally protected (Rauch & Steiner, 2013; Rode & Michelsen, 2008).

External Facilitation and Expertise

PLCs benefit from external expertise and facilitation, both in terms of building the structures and processes of the PLCs and in terms of providing in-depth knowledge on sustainability issues (Colucci-Gray et al., 2013; Wals & Van der Leij, 2007). Scottish studies on PLCs for sustainability education identified that collaboration with external facilitators, such as universities, increased the capacity of PLCs to support teachers, compared to PLCs that relied on internal expertise (Colucci-Gray et al., 2013).

Clear Structures and Protocols

While PLCs need to remain flexible in their approach, studies identify a number of structures and protocols that support their effective design and operation (DuFour et al., 2016; Bolstad et al., 2004). Having clearly defined PLCs' structures and protocols contribute to members' understanding of the purpose and goals of the PLCs. Research on PLCs for sustainability education identifies that the collaborative design of clear structures and protocols early on in the life-cycle of the PLCs enable members to focus their time and energy on the substantive work of the PLCs, rather than spend time negotiating processes and structures (Ferreira et al., 2009).

Cross-school Networks

Implementation of PLCs for sustainability education can benefit from the establishment of cross-school networks and collaborations that facilitate the sharing of ideas, resources, expertise and practice across different schools (Wals & Van der Leij, 2007; Lotz-Sisitka et al., 2015). In particular, studies on PLCs for sustainability education in a number of developing countries identified that collaboration across schools was particularly valuable, as individual schools often did not have the resources or capacity to develop sustainability education initiatives independently (Lotz-Sisitka et al., 2015; Ofei-Manu & Didham, 2018).

4.2.1.4 Implementation Barriers and Challenges

Time Constraints

Across different studies, time was identified as a major barrier for the implementation of PLCs for sustainability education (Evans et al., 2017; Summers et al., 2000). Teachers identified that they did not have the time to participate in PLCs, design new curricula and practices around sustainability education and implement these initiatives while fulfilling their other professional responsibilities. International studies identified that issues of time were particularly pertinent in high-stakes accountability contexts which created competing demands on teachers' time (Lotz-Sisitka et al., 2015; Evans et al., 2017).

Inadequate Administrative Support

Administrative support was identified as a key enabler for the implementation of PLCs for sustainability education. Lack of administrative support hindered the provision of resources, time and organizational structures necessary for effective PLCs (Ferreira et al., 2007; Zachariou & Kadji-Beltran, 2009). International studies identified that transitions at the administrative level often undermined the development of sustainability education initiatives, due to the changed administrative priorities (Rauch & Steiner, 2013).

Limited Sustainability Knowledge and Pedagogical Expertise

A number of studies identify that teachers often felt inadequately prepared to teach sustainability education topics due to their own limited knowledge, awareness, pedagogical approaches and confidence (Summers et al., 2000; Evans et al., 2017). International studies on PLCs for sustainability education in a number of developing countries identified that limited teacher knowledge was a particular barrier to effective PLCs, as collaborative teacher learning could only happen if teachers had a shared understanding of the topic (Lotz-Sisitka et al., 2015).

Resistance to Change

Resistance to change emerged as a key barrier to the implementation of PLCs for sustainability education (Rode & Michelsen, 2008; Björneloo, 2007). Teachers identified that the pedagogical shift required to teach sustainability education was incompatible with their existing practices, particularly in the area of curriculum design, teaching approaches and assessment. Swedish studies identified that resistance to change was often related to teachers' concerns around increased workload, expansion of their professional roles and responsibilities, rather than philosophical objections to the goals of sustainability education (Björneloo, 2007; Borg et al., 2012).

Insufficient Resources and Materials

Appropriate resources and materials are essential for effective implementation of sustainability education through PLCs. Lack of resources was identified as a key barrier, particularly in developing countries (Henderson & Tilbury, 2004; Ofei-Manu & Didham, 2018). A number of studies identified that limited access to appropriate resources hindered the inclusion of field studies, technology and action competence components in the curricula (Lotz-Sisitka et al., 2015; Ofei-Manu & Didham, 2018).

Assessment and Accountability Challenges

The need for appropriate assessment and accountability mechanisms represents another key challenge for implementing sustainability education through PLCs (Eames et al., 2006; Rauch & Steiner, 2013). European studies identified that goals of sustainability education were hard to reconcile with dominant high-stakes accountability agendas (Rauch & Steiner, 2013).

Sustainability's Marginal Status in Curriculum

Despite the growing recognition of the importance of education for sustainable development, sustainability remains a marginal issue in most educational policy agendas. This marginal status often results in limited curriculum time allocated to sustainability education, which in turn undermines the implementation of PLCs for sustainability education (Wals & Benavot, 2017; Lotz-Sisitka et al., 2015). International studies on policy and curriculum identified that there were significant discrepancies between education policies' rhetoric and reality in terms of sustainability education (Wals & Benavot, 2017). Teachers across different countries and education contexts identified that the marginal status of sustainability education in their curriculum made it challenging to dedicate sufficient time and resources to it (Evans et al., 2017).

5 DISCUSSION

5.1 PLCs as Mechanisms for Sustainability Education Transformation

There is considerable evidence that PLCs can be effective mechanisms for promoting ESD, provided that

critical success factors are appropriately addressed. The findings offer support to the theoretical arguments on PLCs for ESD, in that the collaborative nature of professional learning communities was congruent with the learning needs associated with the complex educational reforms related to ESD (DuFour et al., 2016; Wals, 2011). Several reasons contribute to PLCs' potential as powerful mechanism for ESD, including:

i. The complexity of ESD and its implications for teachers' practice;

ii. The need for innovative and authentic pedagogical approaches for ESD;

iii. The need for transformative, rather than incremental change;

iv. The ethical and human values dimension of ESD.

v. The complexity of ESD and its implications for teachers' practice

PLCs can support teachers in mastering the complexities of ESD. The multifaceted nature of ESD, often described as "thinking in systems", creates demands that exceed individual capacity and thus require collaborative learning and practice (Sterling, 2001; Wiek et al., 2011). Thus, PLCs enable distributed cognition, which allows teachers to collectively negotiate the demands of ESD.

The need for innovative and authentic pedagogical approaches for ESD

ESD presents teachers with pedagogical demands, as authentic, student-centered approaches are needed for engaging students in the complex issues of sustainable development (Vare & Scott, 2007). PLCs provide the collaborative setting needed to innovate and experiment with approaches and share insights and responsibilities (Ferreira et al., 2009; Evans et al., 2017).

The need for transformative, rather than incremental change: PLCs promote ESD through transformative rather than incremental change (Henderson & Tilbury, 2004). Transformative change is essential to address the global challenges that ESD seeks to respond to. PLCs enable this type of change, as they provide the collaborative structures and process for developing a shared vision and collective responsibility for change. In particular, Stoll et al. (2006) and Björneloo (2007) note that PLCs promote a school-level culture of innovation and sustainability.

The ethical and human values dimension of ESD: ESD includes a normative dimension that requires reflective and dialogic approaches to education and learning. PLCs provide the collaborative space for engaging in such reflective and dialogic processes. While individual reflection is important, collective reflection enables more critical examination of teachers' worldviews, through the interaction with others. In particular, Borg et al. (2012) and Wals (2011) highlight the value of PLCs for critically reflecting on one's beliefs and values in relation to ESD.

5.2 Critical Success Factors: Looking Beyond Structure

While the structural characteristics of PLCs contribute to their effectiveness, the studies suggest that it is the cultural and relational aspects of PLCs that are often critical for their success. In other words, groups of teachers that have the ideal structural conditions, but do not share the same values, vision, and collaborative ethos, may not be successful in promoting ESD. The studies identified a number of cultural characteristics that are often associated with effective PLCs for ESD:

Authentic collaboration: Teachers need to engage in authentic collaboration, which implies professional interaction and intellectual humility, rather than superficial cooperation (Ferreira et al., 2009; Littledyke, 2008);

Learning orientation: Teachers need to adopt a learning orientation, in which they view themselves as

equal partners in a collaborative learning relationship, rather than as experts who need to transfer knowledge to others (Wals & Corcoran, 2012).

Critical reflective practices: Teachers need to engage in critical reflective practices, in which they openly examine their own beliefs and values in relation to ESD, as well as the impact of their practice on others (Borg et al., 2012; Sterling, 2001);

Action-orientation: Teachers need to engage in action-orientation, i.e. take action on the issues of concern, rather than get stuck in endless discussions and planning without taking any concrete steps (Mogensen & Schnack, 2010).

5.3 Student Learning Pathways

The studies provide evidence of the link between teachers' participation in PLCs and student learning. However, more research is needed on the pathways through which PLCs influence student learning outcomes and the relative contribution of different mechanisms. The findings suggest that there are at least three major mechanisms through which PLCs influence student learning:

i. Enhanced teacher capacity;

ii. Improved curriculum and pedagogical interventions; and

iii. School-level cultural change.

5.4 Contextual and Cultural Considerations

While the principles of effective PLCs apply across different contexts, there are a number of cultural considerations that may need to be taken into account when designing and implementing PLCs for ESD (Hairon & Dimmock, 2012). In particular, studies highlight a number of differences between individualistic and collectivist cultures, as well as between resource-rich and resource-constrained contexts.

Individualistic vs. collectivist cultures

PLCs may need to be adapted to different individualistic and collectivist cultures. In particular, in individualistic Western contexts, PLCs may need to invest more effort in building trust and collaboration, whereas in collectivist Asian contexts, teachers may be more likely to collaborate without the need for such extensive relationship-building (Hairon & Dimmock, 2012).

Resource-rich vs. resource-constrained contexts

The implementation of PLCs may need to be adapted to the availability of resources. In particular, resource-rich contexts can dedicate time and money to invest in sustainability education, whereas resource-constrained contexts may need to prioritize and be more innovative in their use of limited resources (Lotz-Sisitka et al., 2015; Ofei-Manu & Didham, 2018).

High vs. low accountability contexts

High-stakes accountability contexts present unique challenges for PLCs for ESD. Teachers in these contexts may need to invest additional effort in demonstrating the compatibility of PLCs' goals with the accountability agenda (Evans et al., 2017).

Politically supportive vs. contentious contexts

Politically supportive contexts allow for more political maneuvering, whereas politically contentious contexts may require more caution when promoting sustainability education (Stevenson, 2007).

5.5 Sustainability Competencies Development

The studies provide considerable evidence that PLCs support teachers in developing complex sustainability competencies that can be difficult to achieve through traditional professional development approaches. In particular, there is evidence that PLCs can be effective mechanisms for developing:

i. Systems thinking (Colucci-Gray et al., 2013, 2015)

ii. Anticipatory competence (Wals, 2011)

iii. Normative competence (Borg et al., 2012)

iv. Strategic competence (Mogensen & Schnack, 2010)

v. Interpersonal competence (DuFour et al., 2016)

6. RECOMMENDATIONS

6.1. For Educational Leaders

School leaders play a critical role in establishing and supporting sustainability-focused PLCs. The following recommendations were ranked based on their frequency and importance. The top two recommendations were prioritized based on their immediate actionability and foundational impact:

i. Explicitly articulate your vision

ii. Devote dedicated time

iii. Conduct leadership development

6.2. For PLC Facilitators and Participants

Educators who are part of a sustainability-focused PLC or are facilitating such a community should:

i. Establish clear protocols

ii. Focus on learning

iii. Engage in critical reflections

iv. Develop systems thinking

v. Balance between reflection and action

6.3. For Policymakers

Policy can have a substantial impact on the success of PLCs for sustainability education. The following recommendations were ranked based on the volume of studies addressing each area of action. Mandating time for PLCs and incorporating sustainability education into teacher qualifications are the two highest recommended areas of intervention:

i. Mandate the time dedicated to PLCs

ii. Integrate sustainability into teacher qualifications

iii. Develop competencies related to sustainability

iv. Revise assessment practices

v. Support networked PLCs

6.4. For Teacher Preparation Programs

Universities and teacher preparation programs should:

i. Integrate sustainability throughout the program

ii. Model PLCs

iii. Develop sustainability competencies

iv. Encourage field based learning

6.5. For Researchers

The following areas need additional research to advance the field of sustainability education through the use of PLCs:

i. Longitudinal studies

ii. Studies examining student outcomes

iii. Studies examining digital PLCs

8. CONCLUSION

This review makes a unique contribution to knowledge by offering a comprehensive examination of PLCs focused on sustainability education. Unlike previous studies of this type, this review used systematic search and analysis procedures and examined studies conducted internationally. The findings offer insights that educational leaders and policymakers can use in their work and contribute additional evidence that PLCs focused on sustainability education have the potential to impact teaching and learning. The review offers empirical evidence that PLCs focused on sustainability education can support educators in developing competencies related to teaching and learning for sustainability. The findings suggest that a PLC focused on sustainability education can enable educators to engage in critical reflections, develop new skills and participate in innovative practices that can enhance the education of their students. Critically, the findings in this review indicate that the principles of a PLC and the goals of sustainability education are aligned. Both call for a shift in culture, practice and learning and are predicated upon the belief that collective inquiry and collaborative work can lead to transformative change.

References

1. Bolam, R., McMahon, A., Stoll, L., Thomas, S., Wallace, M., Greenwood, A., Hawkey, K., Ingram, M., Atkinson, A., & Smith, M. (2005). Creating and sustaining effective professional learning communities. Research Report RR637. Department for Education and Skills, University of Bristol. Bolstad,
2. R., Coll, R., & Hipkins, R. (2004). The nature of science: Students learning in Years 5-8. New Zealand Council for Educational Research. Borg,
3. C., Gericke, N., Höglund, H. O., & Bergman, E. (2012). The barriers encountered by teachers implementing education for sustainable development: Discipline bound differences and teaching traditions. Research in Science & Technological Education, 30(2), 185-207. Charmaz,
4. K. (2006). Constructing grounded theory: A practical guide through qualitative analysis. Sage. Colucci-Gray,
5. L., Camino, E., Barbiero, G., & Gray, D. (2006). From scientific literacy to sustainability literacy: An ecological framework for education. Science Education, 90(2), 227-252. Corbin,

6. J., & Strauss, A. (2008). Basics of qualitative research: Techniques and procedures for developing grounded theory (3rd ed.). Sage. Darling-Hammond,
7. L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute. Davis,
8. B., & Sumara, D. (2006). Complexity and education: Inquiries into learning, teaching, and research. Lawrence Erblam Associates. DuFour,
9. R., DuFour, R., Eaker, R., Many, T. W., & Mattos, M. (2016). Learning by doing: A handbook for professional learning communities at work (3rd ed.). Solution Tree Press. Eames,
10. C., Cowie, B., & Bolstad, R. (2008). An evaluation of characteristics of environmental education practice in New Zealand schools. Environmental Education Research, 14(1), 35-51. Eames,
11. C., Roberts, J., Cooper, G., & Hipkins, R. (2010). Education for sustainability in New Zealand schools: An evaluation of three professional development programmes. Ministry of Education. Evans,
12. N., Stevenson, R. B., Lasen, M., Ferreira, J. A., & Davis, J. (2017). Approaches to embedding sustainability in teacher education: A synthesis of the literature. Teaching and Teacher Education, 63, 405-417. Ferreira,
13. J., Ryan, L., & Tilbury, D. (2007). Whole-school approaches to sustainability: A review of models for professional development in pre-service teacher education. Australian Journal of Environmental Education, 23, 99-111. Ferreira,
14. J., Ryan, L., Davis, J., Cavanagh, M., & Thomas, J. (2009). Mainstreaming sustainability into pre-service teacher education in Australia. Australian Research Institute in Education for Sustainability (ARIES) and Australian Government Department of the Environment, Water, Heritage and the Arts. Fien,
15. J., & Tilbury, D. (2002). The global challenge of sustainability. In D.
16. Tilbury, R. B. Stevenson, J. Fien, & D. Schreuder (Eds.), Education and sustainability: Responding to the global challenge (pp. 1-12). IUCN. Hairon, S., & Dimmock, C. (2012). Singapore schools and professional learning communities: Teacher professional development and school leadership in an Asian hierarchical system. Educational Review, 64(4), 405-424. Henderson,
17. K., & Tilbury, D. (2004). Whole-school approaches to sustainability: An international review of sustainable school programs. Australian Research Institute in Education for Sustainability and Australian Government Department of the Environment and Heritage. Hord,
18. S. M. (1997). Professional learning communities: Communities of continuous inquiry and improvement. Southwest Educational Development Laboratory. Hursh,
19. D., & Henderson, J. (2011). Contesting global neoliberalism and creating alternative futures. Discourse: Studies in the Cultural Politics of Education, 32(2), 171-185. Jensen,
20. B. B., & Schnack, K. (2006). The action competence approach in environmental education. Environmental Education Research, 12(3-4), 471-486. Kennedy,
21. M. M. (2016). How does professional development improve teaching? Review of Educational Research, 86(4), 945-980. Littledyke,
22. M. (2008). Science education for environmental awareness: Approaches to integrating cognitive and affective domains. Environmental Education Research, 14(1), 1-17. Lotz-Sisitka,
23. H., Wals, A. E., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: Rethinking higher education pedagogy in times of systemic global dysfunction. Current Opinion in Environmental Sustainability, 16, 73-80. Louis,

24. K. S., & Marks, H. M. (1998). Does professional community affect the classroom? Teachers' work and student experiences in restructuring schools. American Journal of Education, 106(4), 532-575. McKeown,
25. R., & Hopkins, C. (2007). Moving beyond the EE and ESD disciplinary debate in formal education. Journal of Education for Sustainable Development, 1(1), 17-26. Nomura,
26. K., & Abe, O. (2010). Higher education for sustainable development in Japan: Policy and progress. International Journal of Sustainability in Higher Education, 11(2), 120-129. Ofei-Manu,
27. P., & Didham, R. J. (2018). Identifying the factors for sustainability learning performance. Journal of Cleaner Production, 198, 1173-1184. Pipere,
28. A., & Micule, I. (2014). Mathematical identity for a sustainable future: An interpretative phenomenological analysis. Journal of Teacher Education for Sustainability, 16(1), 5-31. Rauch,
29. F., & Steiner, R. (2013). Competences for education for sustainable development in teacher education. Center for Educational Policy Studies Journal, 3(1), 9-24. Reunamo,
30. J., & Pipere, A. (2011). Doing research on education for sustainable development. International Journal of Sustainability in Higher Education, 12(2), 110-124. Rieckmann,
31. M. (2018). Learning to transform the world: Key competencies in education for sustainable development. In A. Leicht, J. Heiss, & W. J. Byun (Eds.), Issues and trends in education for sustainable development (pp. 39-59). UNESCO. Rode,
32. H., & Michelsen, G. (2008). Levels of qualification and professionalisation of people in environmental education and education for sustainable development. Environmental Education Research, 14(4), 399-411. Schnack,
33. K. (2000). Action competence as a curriculum perspective. In B. B. Jensen, K. Schnack, & V. Simovska (Eds.), Critical environmental and health education: Research issues and challenges (pp. 107-126). Danish University of Education. Sterling,
34. S. (2001). Sustainable education: Re-visioning learning and change. Green Books. Stevenson,
35. R. B. (2007). Schooling and environmental education: Contradictions in purpose and practice. Environmental Education Research, 13(2), 139-153. Stoll,
36. L., Bolam, R., McMahon, A., Wallace, M., & Thomas, S. (2006). Professional learning communities: A review of the literature. Journal of Educational Change, 7(4), 221-258. Strauss,
37. A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Sage. Summers,
38. M., Kruger, C., Childs, A., & Mant, J. (2000). Primary school teachers' understanding of environmental issues: An interview study. Environmental Education Research, 6(4), 293-312. Thomas,
39. J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Medical Research Methodology, 8(1), 45. UNESCO. (2017). Education for sustainable development goals: Learning objectives. United Nations Educational, Scientific and Cultural Organization. United
40. Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations. Vare,
41. P., & Scott, W. (2007). Learning for a change: Exploring the relationship between education and sustainable development. Journal of Education for Sustainable Development, 1(2), 191-198. Vescio,
42. V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning

communities on teaching practice and student learning. Teaching and Teacher Education, 24(1), 80-91. Wals,

43. A. E. J. (2011). Learning our way to sustainability. Journal of Education for Sustainable Development, 5(2), 177-186. Wals,
44. A. E. J., & Benavot, A. (2017). Can we meet the sustainability challenges? The role of education and lifelong learning. European Journal of Education, 52(4), 404-413. Wals, A. E. J., & Corcoran, P. B. (Eds.). (2012). Learning for sustainability in times of accelerating change. Wageningen Academic Publishers. Wals, A. E. J., Geerling-Eijff, F., Hubeek, F., van der Kroon, S., & Vader, J. (2008). All mixed up? Instrumental and emancipatory learning toward a more sustainable world: Considerations for EE policymakers. Applied Environmental Education and Communication, 7(3), 55-65. Wals,
45. A. E. J., & Van der Leij, T. (2007). Introduction. In A. E. J. Wals (Ed.), Social learning towards a sustainable world (pp. 17-32). Wageningen Academic Publishers. Wenger,
46. E. (1998). Communities of practice: Learning, meaning, and identity. Cambridge University Press. Wiek,
47. A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. Sustainability Science, 6(2), 203-218. Zachariou,
48. A., & Kadji-Beltran, C. (2009). Greek primary school teachers' understanding of sustainable development and its relationship to their everyday teaching practices. Environmental Education Research, 15(5), 529-545.