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Dynamic School Sustainability Index: A Theoretical Framework

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ABSTRACT

K-12 schools rely on periodic, self-reporting sustainability frameworks, including Eco-Schools, Green Ribbon Schools, the Sustainability Tracking, Analytics and Roadmap Tool (START), and the Sustainability Tracking, Assessment & Rating System (STARS). These frameworks share a common architecture: data compiled manually over months and submitted for a credential reflecting conditions from one to three years prior. This architecture produces what institutional theory identifies as ceremonial adoption, in which schools optimize for legibility to evaluators rather than genuine transformation. The gap between institutional sustainability aspirations and operational reality is well documented, yet, to the authors' knowledge, no existing K-12 framework provides the measurement architecture needed to close it. This article addresses that gap by asking what theoretical architecture a K-12 sustainability measurement system requires. In such a system, data accessibility itself functions as a sustainability indicator, and continuous feedback replaces periodic reporting. Drawing on organizational transparency theory, institutional isomorphism, systems thinking, and information ecology, this article develops three elements: the Information Flow Principle, a proportionality principle addressing resource equity, and a three-node architecture organized by the epistemological nature of data streams rather than by sustainability domain. Together these produce gap measurements between curriculum, operations, and institutional identity that existing frameworks cannot generate. The framework offers schools a continuously available account of institutional sustainability coherence rather than a periodic credential, enabling in-year decision-making and reducing the labor burden of periodic reporting. It measures schools as institutions, not student learning outcomes. Empirical validation through prototype implementation in diverse K-12 settings is the next step.

Keywords: K-12 sustainability assessment, Information Flow Principle, institutional sustainability, Whole Institution Approach, education for sustainable development

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INTRODUCTION

K-12 schools seeking to measure and improve their sustainability have access to a range of periodic, self-reporting certification frameworks. These range from international programs such as Eco-Schools (Foundation for Environmental Education, 2024) to national recognition systems such as the U.S. Department of Education Green Ribbon Schools (U.S. Department of Education, 2011). They also include independently developed metrics systems. START, the Sustainability Tracking, Analytics and Roadmap Tool, was developed by the Green Schools Alliance (Green Schools Alliance, 2024). STARS was developed by the Association for the Advancement of Sustainability in Higher Education and applied in K-12 contexts [AASHE] (AASHE, 2024). Despite their differences in scope and emphasis, these frameworks share a common architecture: a school gathers data across dozens of categories, compiles it manually over months, and submits it for a rating or recognition that may reflect conditions from one to three years prior. The result is a credential. It is not a management tool, and it was not designed to be one. In this paper, we propose a framework for iterative improvement through continuous monitoring of sustainability indicators.

The structural limitations of credential-based architecture are well documented in the higher education sustainability literature (Lozano et al., 2015; Pragya & Padmanabhan, 2026; Urbanski & Filho, 2015). Periodic self-reporting produces what DiMaggio and Powell (1983) term ceremonial adoption: surface-level alignment with rating criteria that satisfies external legitimacy requirements without changing underlying institutional practice. When the motivating structure is a submission event occurring every one to three years, institutions optimize for legibility to the evaluator rather than for genuine internal transformation. The rating documents the past, rather than fostering transformation into the future.

These limitations are consequential in K-12 contexts for reasons the higher education literature does not fully capture. Large-scale survey research finds that while 80% of school principals wish for sustainability to be a core element of school education, 62% describe the current reality as non-existent, isolated, or an occasional add-on (Holst et al., 2025). The gap between aspiration and reality is not primarily a knowledge gap or a motivation gap. It is an architectural gap: a failure of the measurement systems available to schools to support the kind of continuous institutional self-knowledge that genuine sustainability transformation requires. The Whole Institution Approach tradition has long argued that sustainability in educational organizations requires aligning curriculum, operations, and institutional culture simultaneously (Henderson & Tilbury, 2004; Holst, 2023). To the authors' knowledge, no existing K-12 sustainability framework provides the measurement architecture through which that alignment can be made continuously visible and actionable. The Greening Education Partnership led by UNESCO is making strides, however, with its Global Dashboard (UNESCO, 2026).

This article proposes such an architecture. The Dynamic School Sustainability Index (DSSI) is a theoretically grounded framework for K-12 sustainability measurement. It is organized around a foundational departure from existing systems: the proposition that data accessibility is itself a sustainability indicator rather than a reporting precondition. This principle, termed here the Information Flow Principle, draws on Davenport and Prusak's (1997) concept of information ecology, which proposes that an organization's information environment is a reflection of its culture, politics, and priorities rather than merely a technical system. While information ecology has been applied across a range of organizational contexts, its application to sustainability measurement in educational institutions has not previously been theorized. The principle holds that the quality of an institution's sustainability-relevant information flow is isomorphic with its organizational sustainability culture. Quality is assessed across four dimensions: presence, accessibility, clarity, and timeliness. These dimensions draw on the information quality literature's recognition that data quality is multi-dimensional and encompasses accessibility and timeliness as distinct organizational concerns (Carvalho et al., 2025; Lee et al., 2002; Wang & Strong, 1996). A school that cannot surface its operational data does not have a measurement problem. It has an organizational problem, and the measurement framework should say so. The

DSSI's three-node architecture organizes sustainability measurement around the epistemological nature of available data streams rather than around sustainability domains. It follows directly from this principle. It produces gap measurements between nodes that existing K-12 sustainability frameworks cannot generate. One is a pedagogical integrity indicator, which reveals whether sustainability education and institutional operations reflect the same commitments. The other is an institutional self-awareness indicator, which reveals whether public identity is grounded in operational reality.

Research Questions

The research questions guiding this framework development are:

1. What theoretical architecture is required for a K-12 sustainability measurement system in which data accessibility functions as a sustainability indicator rather than a reporting precondition?

2. What measurement architecture enables continuous institutional feedback to replace periodic self-reporting as the primary mechanism for sustainability transformation?

The scope of the framework is the school as an institution. It measures sustainability culture, data infrastructure, and operational alignment, not student learning outcomes. The article proceeds as follows. The Literature Review examines three traditions that inform the framework: organizational transparency theory, institutional isomorphism, and systems thinking. The Method section explains how the framework was developed and why no empirical data were collected. The Theoretical Framework then presents the Information Flow Principle, the three-node architecture, and the reframing of assessment as institutional learning. The Discussion addresses implications, limitations, and directions for empirical validation. The Conclusion answers the two research questions.

LITERATURE REVIEW

Three Converging Traditions

The Information Flow Principle sits at the intersection of three bodies of theory: Organizational Transparency Theory, Institutional Isomorphism, and Systems Thinking and Feedback Loop Theory. These theories have developed largely independently and have not previously been synthesized in the K-12 sustainability literature.

Organizational Transparency Theory

Fung et al.'s (2007) targeted transparency framework argues that mandatory disclosure systems change institutional behavior not primarily through external accountability pressure, but by making previously invisible organizational processes visible to decision-makers inside the institution. It changes what an organization knows about itself, and therefore what it can act on. The DSSI extends this argument: it is not enough for data to be technically accessible. Data that is cryptic, inconsistently labeled, or so fragmented that it requires expert interpretation to yield meaning does not produce the internal visibility that drives behavioral change. Clarity and timeliness are not refinements of transparency. They are conditions of it. Applied to K-12 sustainability, this means that building high-quality information flows is not preparatory to sustainability work. It is sustainability work. And where those flows are healthy, the transparency they produce creates the conditions for organizational self-knowledge.

Institutional Isomorphism

DiMaggio and Powell's (1983) foundational analysis of organizational conformity explains why periodic rating systems tend to produce compliance behavior rather than genuine transformation. When the motivating structure is an external submission event, institutions optimize for legibility to the evaluator rather than for

internal coherence. They develop what the literature calls ceremonial adoption: surface-level alignment with rating criteria that satisfies external legitimacy requirements without changing underlying practice (Meyer & Rowan, 1977). STARS and START, however well-designed, are structurally susceptible to this dynamic. Educational leadership research reinforces this concern: sustainable school improvement requires leadership that builds institutional capacity for ongoing self-improvement rather than optimizing for external accountability measures (Hargreaves & Fink, 2006; Leithwood et al., 2020). The DSSI's design responds directly. By treating information flow quality as a scored indicator rather than a reporting precondition, it substantially reduces the scope for ceremonial adoption. It acknowledges, though, that institutions may still find ways to manipulate information systems in pursuit of favorable scores. This structural change reorients the institution's relationship to its own data from periodic compliance to ongoing self-awareness. Argyris and Schon (1978) identify this reorientation as the precondition for organizational learning.

Systems Thinking and Feedback Loop Theory

Meadows' (2008) foundational work on systems dynamics establishes that the behavior of a system is a function of its feedback structure. Systems with long feedback delays cannot self-correct in real time. The gap between action and signal is so long that the causal connection between specific decisions and outcomes becomes invisible. Continuous, high-quality information flows shorten feedback loops to the point where sustainability indicators can actually inform the decisions that produce them. This is not merely a technical improvement over periodic reporting. It is a structural change in the relationship between measurement and institutional learning. It makes possible the kind of ongoing self-correction that Argyris and Schon (1978) describe as single-loop learning. It also creates the conditions for the deeper questioning of institutional assumptions they call double-loop learning.

Together these three traditions converge on a single claim: the architecture of a measurement system is not neutral. It shapes what institutions see, what they optimize for, and what they are capable of learning. The DSSI's architecture is designed with this non-neutrality as a first principle and with institutional sustainability coherence as its horizon.

METHOD

This article is a theoretical and conceptual contribution. It develops new architecture rather than reporting findings from an original empirical study. The approach is appropriate given the state of the field: before a new sustainability measurement system can be empirically tested or implemented, its theoretical foundations must be established, and its design logic made explicit (Jabareen, 2009). The framework's architecture draws on the authors' experience developing two prior K-12 sustainability metrics systems, ProtoSTARS (Eight Schools Association) and START (Green Schools Alliance), both supported by E.E. Ford Foundation grants. It also draws on sustained engagement with the structural limitations of those frameworks in practice.

The framework was developed through a structured synthesis of five bodies of scholarship. These were organizational transparency theory, institutional isomorphism theory, systems thinking and feedback loop theory, the Whole Institution Approach tradition in sustainability education, and the information ecology literature in organizational management. These traditions were not selected independently but identified as convergent responses to a single diagnostic question: why do existing measurement frameworks fail to produce the institutional self-knowledge that genuine sustainability transformation requires? The identification of these traditions followed three steps: backward citation mapping from foundational sustainability assessment critiques, forward citation tracking from seminal works in each tradition, and iterative screening against the criterion of relevance to this central diagnostic question. Traditions were included when they offered distinct theoretical leverage on a specific dimension of the measurement architecture problem that the others did not address. Together they converge on a design logic that no single

tradition generates alone. Foundational sources for the first three traditions are Fung, Graham, and Weil (2007) on organizational transparency, DiMaggio and Powell (1983) on institutional isomorphism, and Meadows (2008) on systems dynamics. Holst (2023) anchors the Whole Institution Approach, and Davenport and Prusak (1997) anchor information ecology.

Following Jabareen's (2009) procedure for building a conceptual framework, the authors mapped and read the relevant literatures through backward and forward citation tracking, identified and named the concepts each tradition contributes, and integrated them into a single architecture, refining it against the central diagnostic question. Jabareen's validation phase corresponds to the prototype implementation described in the Discussion.

No empirical data were collected for this article. The unit of analysis is the school as an institution. The framework's claims are assessed here for their consistency with the literature and for the internal coherence of the architecture. Their empirical assessment is the purpose of the prototype implementation described in the Discussion.

THEORETICAL FRAMEWORK

The organizing principle of the DSSI's architecture, the Information Flow Principle, departs from the domain-based categories used by existing K-12 sustainability frameworks, which reflect stakeholder consensus about what matters. The DSSI instead organizes measurement around the epistemological nature of available data streams: intentional, transactional, and performative. This section develops the principle, the architecture built on it, and the reframing of assessment that follows.

The Founding Assumption and Its Failure

Current measurement frameworks rest on an epistemological assumption about the relationship between data and institutional reality. STARS and START share one: that data about sustainability is separable from sustainability itself. Under this assumption, a school either has data to report or it does not. If it does not, the category is skipped, the score is incomplete, and the framework moves on. Missing data is treated as a measurement problem, not a finding. However, penalizing a school for not having a dedicated sustainability director who can compile waste diversion rates seems to conflate resource inequity with sustainability failure.

But the assumption collapses under scrutiny, and not only at the level of presence or absence. A school that cannot compile its energy consumption data does not have a data problem. It has an organizational problem. More precisely, it has an information flow problem. And information flow, properly understood, is not a binary condition. It exists on a spectrum defined by at least four qualities. These are *presence* (does the data exist?), *accessibility* (can it be retrieved?), *clarity* (is it structured and meaningful rather than cryptic, fragmented, or buried?), and *timeliness* (does it arrive when decisions are being made, or after the moment has passed?) (Carvalho et al., 2025; Lee et al., 2002; Wang & Strong, 1996). The information quality literature establishes that accessibility and timeliness are recognized dimensions of data quality with measurable organizational consequences. The DSSI extends this recognition to sustainability data specifically, treating these dimensions not merely as technical attributes but as indicators of organizational culture and priority.

Each of these qualities tells us something tangible about the institution. A school with energy data that exists but is locked in a facilities manager's spreadsheet has a different organizational profile than one where that data is inaccessible because it was never collected. These are not equivalent measurement gaps to be averaged away. They are diagnostically distinct findings about how the institution operates.

This is the founding theoretical claim of the DSSI, and it requires a name: the Information Flow Principle. Davenport and Prusak's (1997) concept of information ecology holds that an organization's entire information

environment, including how information flows, is created, shared, and valued, reflects its culture and priorities rather than merely its technical capacity. Building on this concept, the DSSI proposes a specific application to sustainability measurement. While information ecology has been applied across a range of organizational contexts, its application to sustainability measurement in educational institutions has not previously been theorized. Stated formally: the quality of an institution's sustainability-relevant information flow, meaning its presence, accessibility, clarity, and timeliness, is itself a primary sustainability indicator, because information flow quality is isomorphic with organizational sustainability culture.

It is worth noting a potential counterexample: an organization may possess sophisticated information systems yet demonstrate weak sustainability practices in the content those systems reveal. The DSSI anticipates this scenario. The Information Flow Principle addresses the quality of data accessibility and transparency, while the node scoring addresses the sustainability content of what is made accessible. High information flow quality combined with poor operational sustainability content is itself a finding of diagnostic value. It reveals an institution that is transparent about its limitations, which is a precondition for improvement, rather than one that obscures them.

The relevant question is not whether a school has enterprise-grade data infrastructure, but whether its information flows represent the sustainability of its operations. A school with limited resources and simple operations that produces clear, accessible, timely data about those operations demonstrates stronger information flow than a well-resourced institution whose operational complexity is matched by equivalent opacity. This proportionality principle has a significant equity implication: resource poverty and data poverty are not the same condition (DiMaggio & Powell, 1983; Fung et al., 2007). A small under-resourced school with simple operations and honest data flows may achieve stronger informational transparency than a large institution with a substantial endowment, extensive facilities, and a global supply chain. Operational complexity amplifies the responsibility for transparency. Complexity is not an excuse for informational opacity. It is an argument for greater urgency in resolving it. Consider two contrasting cases. A small rural primary school has twelve staff, one building, and three vendors. It maintains clear digital records of its energy use, purchasing, and curriculum, so it scores strongly on information flow despite limited resources. By contrast, a well-endowed independent school has extensive facilities, a complex supply chain, and dozens of vendor relationships. It cannot produce accessible procurement data or consistent curriculum documentation, so it scores poorly. The reason is not a lack of resources. Its operational complexity is not matched by informational transparency. The proportionality principle assesses each school against the sustainability implications of its own operations, not against an absolute standard.

This proportionality principle also reframes the relationship between resource constraints and sustainability measurements more broadly. Sophisticated data integration tools can read, aggregate, and interpret heterogeneous data streams automatically. Their availability means that the labor burden of data transparency is no longer proportionate to institutional size (Holst, 2023; Romero & Ventura, 2020). A small school that could never afford a dedicated sustainability director to manually compile data across dozens of categories can now achieve meaningful informational transparency through automated integration. The barrier to participation is no longer primarily financial. It is organizational: a matter of whether the institution is willing to make its operations legible to itself and to its community.

The metaphor here is ecological rather than computational (Capra, 1996; Capra & Luisi, 2014). Healthy ecosystems are characterized by efficient nutrient flows — energy moves through trophic levels, waste becomes resource, signals travel quickly enough to regulate system behavior. Unhealthy ecosystems are characterized by blockages, accumulations, and losses — nutrients pile up where they should not, signals arrive too late to prevent damage, the system cannot self-regulate because it cannot read itself. The data environment of an institution is not a neutral recording of its life. It is an expression of it.

When information flows are healthy across all dimensions simultaneously (clear, accessible, timely, and connected across domains), the conditions are created for something the existing frameworks cannot produce. That something is an institution that knows itself continuously rather than periodically, and that can therefore learn from its own operations in real time. This condition, which this framework terms institutional sustainability coherence, is the horizon toward which the DSSI's architecture points. We will return to it later in this article.

The Three-Node Architecture

The aspiration the DSSI pursues, institutional coherence on sustainability, is not new. The Whole Institution Approach (WIA) tradition was founded by Henderson and Tilbury (2004) and developed through decades of international scholarship. It has long argued that genuine sustainability in educational organizations requires aligning curriculum, operations, and institutional culture rather than treating sustainability as an add-on to an otherwise unchanged system (Holst, 2023; Kohl et al., 2022). A systematic review of 104 international documents defines WIAs as "*continuous and participative organizational learning processes aimed at institutional coherence on sustainability, consistently linking the formal and informal curricula*" (Holst, 2023, p. 1015). This language maps precisely onto what the DSSI is designed to measure. Empirical evidence confirms the scale of this gap. WIA-Scale research finds that only 3.9% of learners and 8.9% of educators report that sustainability is currently practiced in their organization as an everyday institutional reality rather than an occasional add-on (Holst et al., 2024). The DSSI does not claim the aspiration, because the WIA tradition already established it. The DSSI's contribution is the measurement architecture through which that coherence becomes visible, continuous, and actionable. Neither STARS, START, nor the WIA framework itself has yet provided this.

The three-node structure of the DSSI (Learning, Operations, Identity) is not a categorization scheme imposed on sustainability domains, as in STARS and START, where categories were developed through stakeholder deliberation about what matters. The nodes are epistemological categories derived from the nature of available data streams and the conditions under which institutional sustainability can be known. Three fundamentally different kinds of data exist in any school. Intentional data is created because people choose to document something. Transactional data is created as a byproduct of institutional activity. Performative data is created because the institution chooses what to make visible to external audiences. Any sustainability-relevant data a school generates can be located within this architecture according to the nature of its creation. The nodes are not a statement about what sustainability domains matter. They are a statement about how institutions can be known.

This distinction has a practical consequence that existing frameworks cannot match. Because the nodes are organized by data type rather than by domain, no sustainability-relevant activity falls outside the architecture. Governance decisions appear in Node 2 as budget allocations, vendor contracts, and policy implementation. These are transactional data. Governance communications appear in Node 3 as board statements and institutional policies made public. These are performative data. Governance education appears in Node 1 as curriculum and student learning, which are intentional data. The framework does not need a separate governance category because governance is already distributed across all three nodes according to where its data naturally lives. The relationships among the three nodes and the gap measurements between them are illustrated in **Figure 1**.

Node 1: Learning

Node 1 asks: what is the institution developing in its students? The data here is intentional. It exists because people choose to create it through tagging, logging, and connecting curriculum to competency frameworks and student action to the UN Sustainable Development Goals (SDGs).

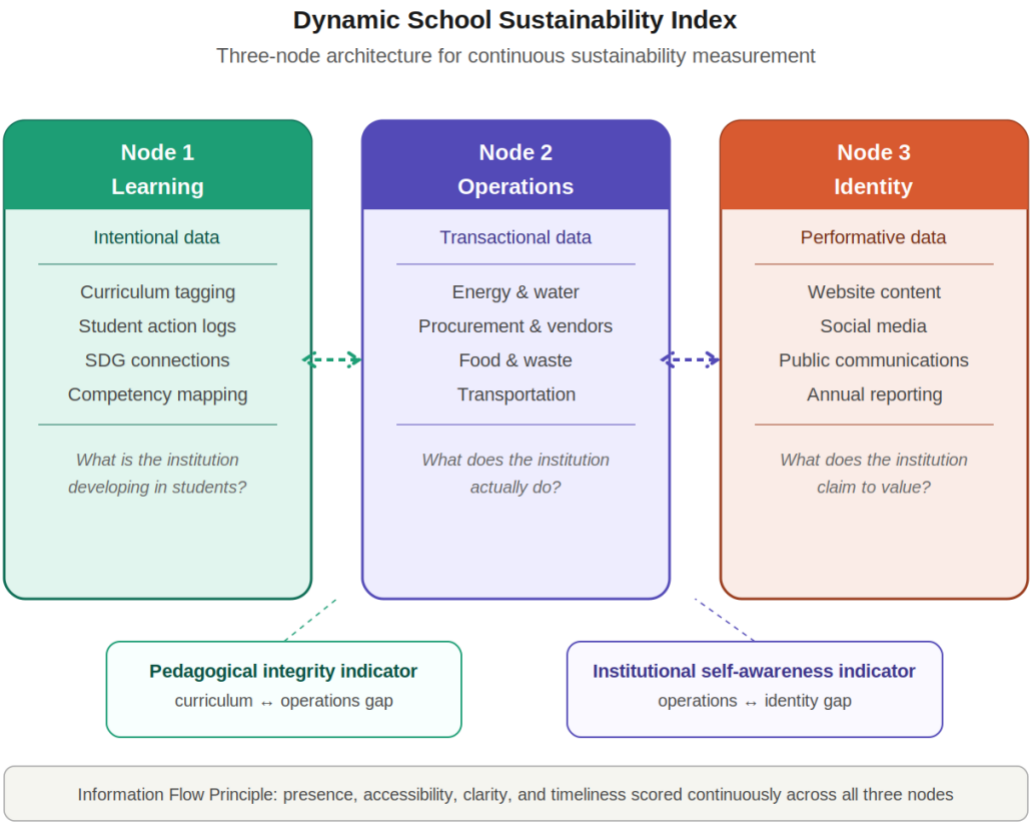


Figure 1. The DSSI three-node architecture showing the relationships among Node 1 (Learning), Node 2 (Operations), and Node 3 (Identity), the pedagogical integrity indicator (Node 1–Node 2 gap), and the institutional self-awareness indicator (Node 2–Node 3 gap), with the Information Flow Principle operating continuously across all nodes (Source: The authors)

The theoretical anchor is the Education for Sustainable Development (ESD) competency literature, particularly Redman and Wiek's (2021) expansion of the key competencies framework to eight dimensions (Wiek et al., 2011). This node is developmentally differentiated. Sustainability competency looks different across the K-12 age span, and frameworks that ignore this produce category errors (Chawla, 1999; Davis, 2009; Sposab & Rieckmann, 2024). The information flow question is whether curriculum documentation and student action logging are clear, consistent, and connected to a competency framework, or whether sustainability learning is happening invisibly, inaccessible to the institution's own self-understanding. The WIA-Scale research confirms that the degree to which sustainability is experienced as an everyday institutional reality is the strongest predictor of effective learning outcomes (Holst et al., 2024). Indicators include the proportion of courses with mapped sustainability competencies, hours of student sustainability action logged against SDGs, and the percentage of faculty participating in ESD professional development.

Node 2: Operations

Node 2 asks: what does the institution actually do? The data here is transactional. It exists as a byproduct of institutional activity in purchasing, procurement, energy consumption, water use, waste, and transportation. This node is grounded in the GHG Protocol's Scope 3 methodology, which establishes that an institution's full sustainability footprint extends through its entire vendor and supply chain ecosystem (Swensson & Tartanac, 2025; Walker & Brammer, 2009; World Resources Institute & World Business Council for Sustainable

Development, 2011). The information flow question is whether transactional data is digitized, consistently formatted, and accessible, or locked in paper invoices and siloed across departments. When operational information flows are healthy, the institution can see the sustainability implications of its daily decisions in something close to real time. This is how sustainability becomes embedded in institutional culture rather than layered on top of it, what the WIA tradition describes as a school becoming a "living laboratory" (Holst, 2023). Indicators include energy and water consumption normalized per student, percentage of food spend meeting Responsible Epicurean and Agricultural Leadership (REAL) Food or equivalent certification, proportion of vendors with third-party sustainability certification, and waste diversion rates.

Node 3: Identity

Node 3 asks: what does the institution claim to value? The data here is performative. It exists because the institution chooses what to make visible to external audiences through its website, social media, and public communications. All institutions communicate selectively and strategically (Cheney & Christensen, 2001; Cheney et al., 2014). Node 3 does not treat this as a problem to be corrected. It treats it as a data stream to be read. The information flow question is whether public sustainability communications are specific, evidence-based, and sustained across the year, or concentrated around particular events and disconnected from operational reality. When the flow is thin or purely aspirational, it reveals a gap between self-image and self-knowledge (Dutton & Dukerich, 1991), a pattern confirmed in educational sustainability reporting (Lakhno, 2024). Indicators include the frequency and specificity of sustainability communications across channels, the proportion of public claims grounded in operational data, and the consistency of sustainability messaging across the academic year rather than concentrated around environmental calendar events.

The relationships between nodes are as theoretically significant as the nodes themselves. The gap between Node 2 and Node 3 is the framework's primary institutional self-awareness indicator. It measures the distance between what an institution does and what it says it values. It is not a measure of intent. It is a measure of the degree to which a school's public identity is grounded in operational reality. A school whose public communications consistently outrun its operational data is not necessarily misleading its community. It may simply lack the continuous self-knowledge to see the gap. That gap is itself an information flow problem. The institution's identity and its operations are not in dialogue because the data flows that would connect them do not exist. The gap between Node 1 and Node 2 is its pedagogical integrity indicator. It measures the distance between what students are taught and what the institution practices, and it reveals whether sustainability education and institutional operations are expressions of the same commitments or parallel tracks that never intersect. The WIA tradition identifies exactly this alignment as the defining characteristic of a genuinely sustainability-oriented school (Henderson & Tilbury, 2004; Holst, 2023). Neither gap measurement is available to any existing K-12 sustainability framework, because no existing framework holds intentional, transactional, and performative data simultaneously and continuously. While empirical validation lies beyond the scope of this article, the gap indicators lend themselves to conceptual operationalization. The pedagogical integrity indicator could be measured as the correlation between Node 1 competency coverage scores and Node 2 operational sustainability scores. A school teaching supply chain ethics while purchasing from uncertified vendors produces a measurable divergence. The institutional self-awareness indicator could be measured as the degree of correspondence between Node 3 communication claims and Node 2 operational data. This quantifies the distance between what is said publicly and what the data shows.

The Role of Artificial Intelligence

The DSSI's continuous data integration is enabled by artificial intelligence systems that can read institutional data from multiple sources, interpret it in context, and surface findings in real time. Recent scholarship documents three relevant capabilities. AI can automate sustainability data collection and integration across fragmented institutional sources (Mustafa et al., 2025). It can apply natural language processing to institutional communications to evaluate the specificity, consistency, and grounding of sustainability claims (Calamai et

al., 2025; Kim et al., 2023). It can also cross-reference public disclosures against operational data to identify gaps between institutional identity and operational reality (Janice & Delina, 2024). This literature is situated primarily in corporate Environmental, Social, and Governance (ESG) and higher education contexts. Applying these capabilities to K-12 sustainability measurement is a next step that the DSSI's theoretical architecture is designed to make possible. These capabilities raise important implementation considerations. They include data privacy and student confidentiality, algorithmic bias in sustainability assessments, cybersecurity risks associated with integrating institutional data systems, and the varying levels of technological readiness across K-12 schools. They also include the environmental costs of the AI systems themselves, including the energy and water consumption associated with data center operations (Li et al., 2025). It bears noting that the framework's theoretical claims are technology-agnostic. The Information Flow Principle holds regardless of the mechanism by which data flows are read and evaluated. AI represents the first technology capable of operationalizing this architecture at the scale and continuity K-12 institutions require. The architecture itself, however, is not defined by any particular technology and should be understood as designed to evolve alongside the tools available to implement it.

Reframing Assessment as Institutional Learning

The final theoretical move is a reframing of what sustainability assessment is for. STARS and START are accountability instruments. They produce a credential that signals institutional legitimacy to external stakeholders (Lozano et al., 2015; Pragya & Padmanabhan, 2026; Urbanski & Filho, 2015). This is a legitimate and valuable function. But it is not a learning function, and conflating the two has produced frameworks that serve neither purpose fully. These sources draw primarily on higher education contexts. The DSSI represents an extension and adaptation of this critique to the K-12 sector, where smaller staff capacity and greater dependence on periodic external validation make the accountability/learning distinction even more consequential.

The DSSI is designed as a learning instrument in the sense Argyris and Schon (1978) intended: a mechanism through which an institution detects and corrects errors in its own sustainability practice. Single-loop learning, which corrects deviations from existing goals, is supported by continuous feedback within each node. Double-loop learning, which questions whether the goals themselves are adequate, is supported by the gap measurements between nodes, which surface contradictions that periodic snapshots miss.

Sterling's (2001, 2011) three orders of change map directly onto this distinction: learning about sustainability, learning for sustainability, and learning as sustainability. A framework designed only for accountability operates at the first order. The DSSI aspires to create conditions for the second and third, not by measuring transformation directly but by building information flows healthy enough that transformation becomes possible from within. The WIA tradition describes this as institutions enacting sustainability as an organizational default rather than performing it for external audiences (Holst, 2023).

Institutional sustainability coherence, as this framework understands it, is not an abstract condition. It is observable. It is present when curriculum and operations are in genuine dialogue: when a teacher developing a unit on supply chain ethics can see the school's actual procurement data, when a facilities decision about energy is visible to the science department teaching climate. It is present when public communications are specific enough to be grounded in operational reality rather than running ahead of it. It is present when the school's stated values, its daily operational choices, and its educational program are recognizably expressions of the same institutional commitments rather than parallel tracks that never intersect. The WIA research confirms that when learners and educators actually experience this alignment on an everyday basis, sustainability learning outcomes are substantially stronger (Holst et al., 2024).

This condition cannot be achieved by optimizing any single node in isolation. It requires healthy information flows across all three nodes simultaneously. Intentional, transactional, and performative data must be in

genuine conversation with each other, so that the institution is not just measuring its sustainability but continuously learning from it. That is what current frameworks cannot produce. The DSSI's deepest claim is simply this: that measurement architecture matters. That how you measure shapes what you see, what you learn, and what you become capable of. And that K-12 schools deserve a measurement system designed not to credential their past but to develop their future.

DISCUSSION

The theoretical architecture developed here makes possible a class of findings that no existing K-12 sustainability framework can generate. The gap between Node 2 and Node 3 gives a school a continuously available answer to a question that periodic frameworks cannot ask: does what we say about our sustainability commitments match what our purchasing, energy, and procurement data actually show? This is the gap between operational reality and public identity. The gap between Node 1 and Node 2 answers a different but equally consequential question: is sustainability education connected to institutional practice, or are they parallel tracks that happen to share a campus? This is the gap between curriculum and operations. Under STARS, START, Eco-Schools, or Green Ribbon, a school might score well on operations and well on curriculum and never discover that the two have nothing to do with each other. The DSSI makes that discovery structurally unavoidable. This is the practical meaning of institutional sustainability coherence. It is not a score. It is the capacity to see one's own institution as a connected system rather than as a set of independently reported categories.

This capacity has a particular significance for schools without dedicated sustainability staff. The architecture is organized around data streams that already exist, such as utility records, purchasing systems, curriculum platforms, and public communications. It is not organized around a reporting process that must be staffed and managed. A school's participation therefore depends less on having personnel available to compile a submission and more on whether its existing systems are connected and legible. This does not mean participation becomes costless. It means the cost shifts from periodic labor-intensive compilation to the more tractable, one-time work of connecting data systems that already exist. The proportionality principle developed earlier suggests what this means in practice. A small school with simple, well-connected systems may achieve stronger information flow than a large school with sophisticated but siloed ones, regardless of which school has more staff capacity.

Transition from existing frameworks to the DSSI would occur in stages rather than as a wholesale replacement. An initial phase would focus on data infrastructure assessment: identifying which institutional data systems are already digital and accessible, which require digitization, and which data streams need new collection mechanisms. A second phase would connect existing systems to the DSSI's node architecture, prioritizing Node 2 operational data where transactional records already exist in digital form. Node 1 would require deliberate faculty engagement to establish curriculum tagging and student action logging practices. Node 3 requires the least infrastructure investment since public communications are already digital. Schools already participating in STARS, START, or equivalent frameworks would find that much of the data those frameworks require is already organized within the DSSI's architecture, reducing rather than adding to reporting burden.

These implications come with limitations that should be stated plainly. The framework developed here is theoretical. It has not been implemented, and the institutional sustainability coherence it describes has not been empirically observed using this architecture. The next step in this research program is prototype implementation in K-12 settings, through which the framework's claims become testable. Three questions would guide it. First, does the four-dimensional information flow assessment produce meaningful and stable distinctions between schools? Second, do the node gap measurements correlate with outcomes that matter? Third, does the proportionality principle function as intended when applied to schools of genuinely different scale and complexity?

Prototype implementation would take the school as the unit of analysis. A first phase would apply the scoring methodology to a small set of schools that differ in size, resources, and data infrastructure, and examine whether the information flow assessment distinguishes among them in ways school leaders recognize as accurate. A second phase would test whether the node gap measurements track independent evidence of coherence, such as differences between a school's public claims and its documented practice. The framework's central claim would gain support if scores differentiate schools consistently across repeated assessments. It would be weakened if scores tracked school size or wealth rather than information practices, or if gap measurements proved unstable between assessments. Later studies could examine whether institutional coherence relates to student learning outcomes, a question the framework makes testable but does not itself address.

A related limitation concerns the AI capabilities the architecture depends on. The literature establishing that AI can integrate heterogeneous institutional data, evaluate the specificity of public communications, and cross-reference disclosures against operational records is well developed in corporate ESG and higher education contexts (Janice & Delina, 2024; Kim et al., 2023; Mustafa et al., 2025). Its application to K-12 institutional data, which differs from corporate ESG data in scale, structure, and the kinds of systems involved, has not been demonstrated. Prototype implementation will need to treat this as an empirical question rather than an assumption.

A further limitation concerns Node 1 specifically. Node 1 differs from Nodes 2 and 3, which can in principle be assessed largely through automated reading of existing records and public communications. Node 1 depends on intentional human behavior: faculty tagging curriculum, students logging service hours, and the explicit connection of activities to competency frameworks and SDGs. No degree of automation eliminates this dependency, because the data Node 1 measures does not exist until people choose to create it. This is not a flaw in the architecture. It is a structural feature with a clear implication. A school's Node 1 information flow score reflects not only its sustainability culture but the specific degree to which faculty and students have been given the tools, time, and institutional support to document what they are already doing.

The DSSI's relationship to existing frameworks is best understood as complementary rather than substitutive. STARS, START, Eco-Schools, and Green Ribbon Schools serve a credentialing function this framework does not replace and was not designed to replace: external recognition that signals a baseline of institutional commitment to stakeholders, prospective families, and accreditors. A school's participation in the DSSI does not preclude pursuing these credentials. The continuous data integration the DSSI describes would, as a byproduct, make compiling submissions to those frameworks considerably less burdensome, because much of the data those frameworks request would already be organized and current. The DSSI's contribution is not to displace the credential but to provide what the credential cannot: a continuously available answer to the question of where an institution actually stands. That answer is available not once every one to three years but at any point a stakeholder asks.

A further limitation concerns the framework's generalizability across educational systems. The DSSI was developed in a North American independent school context with relatively robust digital infrastructure. Its applicability in developing country contexts, where digital systems, reliable energy, and internet connectivity cannot be assumed, requires careful consideration. In such contexts, the proportionality principle remains theoretically sound, but the enabling role of AI-powered data integration may not be available, and analogue data collection processes may need to substitute for automated systems. Scalability across national educational systems with different governance structures, funding models, and sustainability policy frameworks also represents an open question that prototype implementation should address across diverse contexts.

Finally, the theoretical traditions this framework draws on, namely organizational transparency theory, institutional isomorphism, information ecology, and much of the sustainability assessment literature, were

developed primarily in corporate and higher education contexts. The Whole Institution Approach tradition, which is more directly K-12 relevant, establishes the aspiration this framework operationalizes but does not itself provide a measurement architecture. Extending these traditions to K-12 institutions is therefore part of this article's contribution. It also raises an open question. K-12 schools differ from universities and corporations in their relationships with families and communities, in the developmental stakes of Node 1, and in the smaller scale of their operations. Prototype implementation will need to establish whether these conditions require modifications to the architecture beyond the proportionality principle and the developmental differentiation of Node 1.

CONCLUSION

The research questions guiding this article asked two things. The first was what theoretical architecture is required for a K-12 sustainability measurement system in which data accessibility functions as a sustainability indicator rather than a reporting precondition. The second was what measurement architecture enables continuous institutional feedback to replace periodic self-reporting as the primary mechanism for sustainability transformation.

The answer to the first question has three parts. It requires an Information Flow Principle that treats the presence, accessibility, clarity, and timeliness of an institution's sustainability-relevant data as diagnostic of its sustainability culture. This extends Davenport and Prusak's (1997) information ecology concept to a context it has not previously been applied to (Davenport & Prusak, 1997; Wang & Strong, 1996). It requires a proportionality principle that calibrates this standard to operational complexity. This ensures that the framework measures honesty and connectedness rather than scale, and that resource constraints are not conflated with cultural failure. And it requires an architecture organized around the epistemological nature of available data (intentional, transactional, and performative) rather than around the sustainability domains that have organized every prior framework. This is what produces the gap measurements between curriculum and operations, and between operations and identity, that no existing system can generate (DiMaggio & Powell, 1983; Holst, 2023).

The answer to the second question is the three-node structure itself. By organizing measurement around data streams that update continuously rather than around a periodic submission cycle, the DSSI produces gap measurements between curriculum, operations, and institutional identity. These measurements are only visible when all three nodes are held simultaneously and in real time. The pedagogical integrity indicator (the gap between Node 1 and Node 2) and the institutional self-awareness indicator (the gap between Node 2 and Node 3) are not available to any framework that relies on periodic snapshots. They require the institution to be known across all three dimensions at the same moment. Continuous feedback is not merely a technical improvement over periodic reporting. It is the precondition for the kind of institutional self-knowledge that genuine sustainability transformation requires (Argyris & Schon, 1978; Meadows, 2008).

None of the elements in either answer is sufficient alone. Together they constitute what this article has called institutional sustainability coherence. It is not a score a school receives but a condition a school can come to occupy, in which its curriculum, its operations, and its public identity are recognizably expressions of the same commitments rather than three separate stories told to three separate audiences.

The Whole Institution Approach tradition named this aspiration two decades ago and has watched it remain, for most schools, an aspiration rather than a reality (Holst et al., 2025). The architecture proposed here does not close that gap by itself. What it offers is a way of seeing the gap continuously, which is the precondition for closing it. A measurement system that can only describe a school's past gives that school no information about where to look next. A measurement system that describes a school's present, continuously, gives it something

a credential never could: the ability to ask, at any moment, whether today's decisions are taking it where it says it wants to go.

The DSSI's implications extend beyond individual schools to educational policy and school leadership. For policymakers, the framework suggests that sustainability mandates without accompanying data infrastructure investment will produce ceremonial compliance rather than genuine transformation. This has direct implications for how sustainability requirements are designed and resourced. For school leaders, the framework reframes sustainability measurement as an instrument of institutional self-knowledge rather than external accountability. This shift positions the sustainability director not as a compliance officer but as an architect of the school's capacity to understand and improve itself. Future empirical research should prioritize prototype implementation across schools of varying size, resource level, and national context. It should pay particular attention to whether the Information Flow Principle's core claim, that data accessibility is isomorphic with sustainability culture, holds across diverse institutional settings.

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