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METRICS IN INTEGRATED CONCURRENT ENGINEERING (ICE): INSIGHTS, CHALLENGES, AND OPPORTUNITIES

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ABSTRACT

The Norwegian construction industry has experienced a 10% productivity decline since 2000, in stark contrast to a 30% increase in the Norwegian private sector. To address this issue, Virtual Design and Construction (VDC)—including Integrated Concurrent Engineering (ICE)—has gained prominence. Although metrics are central to ICE sessions for guiding decision-making and fostering continuous improvement, their practical usage often falls short of theoretical ideals. This paper investigates current measurement practices, the challenges they pose, and strategies for more effective implementation. A qualitative study involving semi-structured interviews with eight industry experts was conducted, and data were analysed using thematic coding. Findings indicate that while practitioners value metrics—particularly meeting evaluation surveys, PPC (Percent Plan Complete), and BIM-focused indicators—their deployment is hindered by participant selection problems, underutilized data, and technological incompatibilities. The study proposes a multi-pronged approach for improvement: automation of data collection, standardization of measurement protocols, fostering an open data-sharing culture, and continuous review of metric relevance. These recommendations aim to bridge the gap between theoretical metrics frameworks and day-to-day industry practices, ultimately enhancing productivity and project outcomes.

KEYWORDS

Virtual Design and Construction (VDC), Integrated Concurrent Engineering (ICE), Metrics, Continuous Improvement, Lean Construction

INTRODUCTION

Since 2000, productivity in the Norwegian construction industry has declined by 10%, while the mainland private sector has grown by 30% (Todsen, 2018). In response, Virtual Design and Construction (VDC) has been increasingly adopted to improve project efficiency and outcomes (Belsvik et al., 2019). VDC integrates Building Information Modelling (BIM), Integrated Concurrent Engineering (ICE), metrics, and Project Production Management (PPM) (Kunz & Fischer, 2012; Rischmoller et al., 2018). Among these, ICE is particularly critical, as it facilitates multidisciplinary collaboration and structured decision-making through real-time interaction and iterative improvement cycles such as Plan-Do-Check-Act (PDCA) (Kunz & Fischer, 2020).

Despite the recognized importance of metrics in ICE sessions, their actual use in practice often falls short of theoretical ideals. While literature emphasizes the role of metrics in

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enhancing decision-making, tracking performance, and fostering continuous improvement, empirical research suggests significant inconsistencies in how ICE metrics are applied across projects (Majumdar et al., 2022). Previous studies have examined general VDC metrics (Belsvik et al., 2019), but there is limited research on how specific ICE-related metrics are implemented, the challenges practitioners face, and how these challenges impact decision-making efficiency.

This study addresses this gap by examining how ICE metrics are currently used in practice, the challenges limiting their effectiveness, and potential strategies for improvement. Specifically, the study aims to:

- Analyse the practical application of ICE metrics in Norwegian construction projects.
- Identify key challenges affecting metric usage, including technical, organizational, and behavioural factors.
- Propose strategies for improving ICE metric implementation to enhance decision-making and project performance.

LITERATURE REVIEW

INTEGRATED CONCURRENT ENGINEERING (ICE)

Integrated Concurrent Engineering (ICE) is a systematic approach that unites all key stakeholders—architects, engineers, and contractors—from a project's early stages to design products and their processes simultaneously (Kunz & Fischer, 2020; Del Savio et al., 2022). Inspired by NASA's "Extreme Collaboration" and developed at CIFE, ICE is embedded within the Virtual Design and Construction (VDC) framework to improve quality, cost, schedule, and user requirements.

ICE is particularly effective for tasks with reciprocal dependencies requiring continuous information exchange (Kunz & Fischer, 2020; Quiso et al., 2021). Unlike parallel or sequential tasks, these reciprocal tasks benefit from structured sessions where decision-makers meet with clear agendas. Digital tools like BIM and simulations further aid in visualizing and resolving interdependencies.

A key advantage of ICE is its ability to enable rapid, low-latency communication by co-locating decision-makers, which minimizes delays and reduces reliance on inefficient channels like email (Rischmoller et al., 2018). Enhanced coordination in ICE sessions has led to measurable improvements—for instance, a 25% reduction in delays and a 15% cost decrease in road infrastructure projects in Peru (Zavala et al., 2024). Coupled with Project Production Management (PPM) and Lean principles, ICE boosts transparency, engagement, and stakeholder ownership of outcomes.

The ICE process follows an iterative "accordion" model, alternating between collaborative sessions and individual work phases. This balance ensures team alignment during group interactions while allowing in-depth analysis and continuous improvement through performance metrics (Quiso et al., 2021; Del Savio et al., 2022).

METRICS AND CONTINUOUS IMPROVEMENT IN VDC

Metrics are central to VDC, documenting project efforts, enhancing efficiency, and guiding the design process. As Drucker and Maciariello (2008) note, effective controls must address both past performance and future expectations (Belsvik et al., 2019; Knotten & Svalestuen, 2014). VDC emphasizes process-oriented measurements to continuously evaluate team performance during project execution.

Kunz and Fischer (2012) categorize VDC goals and measurements into three areas: 1) *Project Goals* – Assessed at project completion against initial cost, schedule, quality, and safety

targets; 2) *Production Measurements* – Frequent (daily or weekly) assessments tracking progress; 3) *Controllable Factors* – Actions and decisions by project leaders that shape daily operations.

VDC utilizes a range of metrics—including those from ICE, BIM, and PPM—to monitor and enhance operational efficiency (Majumdar et al., 2023; Majumdar et al., 2022). The Plan-Do-Check-Act (PDCA) cycle reinforces continuous improvement by celebrating successes, addressing shortcomings, and refining processes in real time (Kunz & Fischer, 2020).

Simple metrics can yield substantial efficiency gains by reducing tasks like quantity take-off and increasing the percentage of planned completions through root-cause analysis (Knotten & Svalestuen, 2014; Lee et al., 2020). Integrating Lean Construction with VDC further eliminates waste (e.g., excess motion, overproduction), streamlining operations and driving performance improvements (Mandujano et al., 2016; Alarcón et al., 2013).

Despite these benefits, establishing meaningful, standardized metrics remains challenging due to the lack of a common vocabulary and reliance on anecdotal evidence. Standardized protocols and consistent data visualization are essential for effective benchmarking and collaboration (Majumdar et al., 2022; Alarcón et al., 2013).

Case studies reinforce the practical benefits of VDC metrics. For example, 5D BIM models have improved client satisfaction and reduced technical barriers (Lee et al., 2020; Lee et al., 2022), while planning and control frameworks help contractors avoid performance issues and cost overruns by accurately estimating time and budget requirements and closely monitoring VDC tasks (Said & Reginato, 2018).

ICE METRICS IN THE LITERATURE

Several studies highlight the importance of specific metrics in ICE sessions. Table 1 summarizes metrics reported in the literature, followed by a discussion of their application.

Table 1 ICE metrics reported in the literature

ICE Measurements	Kunz & Fischer (2012)	Belsvik et al. (2019)	Balcazar et al. (2023)	Fosse & Ballard (2016)	Knotten & Svalestuen (2014)	Correa (2020)
Meeting attendance (%)	X					X
PPC of ICE sessions (%)		X	X		X	
Meeting evaluation metrics		X		X	X	
Satisfaction with others' input				X		
Response latency (hours)	X					
Decision latency (hours)	X	X				
Decision stickiness (#)		X				
Meeting cost (NOK)		X				
Plus/Delta		X				
Value-adding activities (%)	X					

- *Meeting Attendance (%):* Tracks participation, with Correa (2020) noting its impact on meeting outcomes.
- *PPC of Sessions (%):* Measures the percentage of planned tasks completed; used to assess agenda effectiveness (Belsvik et al., 2019; Balcazar et al., 2023; Knotten & Svalestuen, 2014).
- *Meeting Evaluation Metrics:* Post-session surveys evaluate preparation, relevance, and productivity; the Plus/Delta method helps identify strengths and areas for improvement (Belsvik et al., 2019; Fosse & Ballard, 2016; Knotten & Svalestuen, 2014).
- *Response Latency (Hours):* Time between inquiry and receipt of quality information, highlighting efficiency improvements (Kunz & Fischer, 2020).
- *Decision Latency (Hours):* Time from decision request to decision made; longer latencies can delay projects (Kunz & Fischer, 2012; Belsvik et al., 2019).
- *Decision Stickiness (#):* Frequency of changes in decisions, where high stickiness may signal instability (Belsvik et al., 2019).
- *Meeting Cost ($):* Evaluates the expense of holding meetings to determine cost-effectiveness (Belsvik et al., 2019).
- *Value-Adding Activities (%):* Assesses the share of meeting time spent on tasks that directly contribute to decision-making versus non-value adding activities (Kunz & Fischer, 2012; Majumdar et al., 2022).

METHOD

This study employed a qualitative survey design using semi-structured interviews to explore complex issues related to ICE methodology. Guided by Tjora (2017), the approach balanced a predefined interview guide with the flexibility to ask follow-up questions, ensuring rich, in-depth data.

Eight industry experts were selected via purposive sampling based on their specialized knowledge of ICE and VDC certification. Contact was initiated through a recognized industry figure, Eilif Hjelseth, who provided a list of qualified VDC mentors. Out of 12 invited experts, seven agreed to participate, and one additional expert was included after an initial discussion. The participants, with diverse roles (entrepreneurs, advisors, and a building owner) and extensive experience (from 5+ to 20+ years, as shown in Table 3), provided a solid foundation for reliable insights.

Each interview lasted between 40 and 70 minutes and was conducted digitally via Microsoft Teams. Following Tjora's model, the interviews began with simple warm-up questions, proceeded with reflective queries to explore personal experiences, and concluded with summary questions to capture key insights. All sessions were audio recorded (with explicit consent) and supplemented by notes to ensure clarity..

Recordings were immediately reviewed for quality and securely backed up. Automatic transcripts were manually corrected for accuracy, removing filler words and refining clarity. Thematic coding—guided by Tjora (2017)—was then applied: initial codes were established with the first interview and iteratively refined across subsequent sessions. Codes were organized into themes (e.g., preparation, execution, challenges) using Microsoft Excel, allowing systematic identification of patterns and relationships within the data.

To boost reliability, the study employed verbatim transcriptions, careful manual corrections, and systematic coding. Validity was enhanced by grounding questions in both theoretical and practical insights. Open-ended questions and follow-ups minimized misinterpretations, while the structured interview phases helped mitigate potential interviewer bias. An

overrepresentation of entrepreneurs was noted, which may influence the findings; this limitation is discussed further in later sections.

RESULTS

HOW ARE MEASUREMENTS USED IN ICE SESSIONS TODAY (RQ-1)?

This subsection addresses Research Question 1 by examining how metrics are currently applied in ICE sessions and which types of measurements are most commonly used by practitioners.

Informants agreed metrics should provide actionable insights for continuous improvement, describing metrics as a 'speedometer' to help teams adjust execution. Metrics were viewed as essential tools for process improvement, offering a structured way to evaluate performance. Although few participants explicitly referenced the Plan-Do-Check-Act (PDCA) framework, many described using metrics to assess outcomes ("Check") and determine necessary adjustments ("Act"). Several informants emphasized that metrics increase transparency and accountability, helping to document progress, clarify objectives, and ensure that participants come prepared. One informant compared this preparatory effect to "homework," noting that when participants know they will be measured, they tend to be more engaged.

In more complex or contentious project situations, metrics were seen as a way to introduce objectivity into discussions and support decision-making. In these cases, metrics reduced reliance on subjective judgment and strengthened the case for process changes.

Informants identified several key metrics used in ICE practice. Their applications and significance are summarized below to contextualize how practitioners integrate measurement into their workflows:

- **Meeting Evaluation Metrics**: All informants reported using post-session evaluation tools, most commonly anonymous surveys. These included the Plus/Delta method, which captures both positive aspects ("plus") and areas for improvement ("delta"), and scaled assessments (e.g., 1–6) evaluating preparation, facilitation, and content relevance. Aggregated results were often shared in plenary discussions to highlight strengths and target improvements. Key controllable factors identified through these evaluations include the agenda's structure, participant preparation, and the relevance of each participant's role. Adjustments based on these insights often focused on balancing agenda priorities, refining time estimates, and ensuring the presence of appropriately selected participants. These metrics are typically used for real-time feedback loops and are closely tied to session facilitation quality.'
- **Percentage of Agenda Items Achieved (PPC of Sessions):** This adaptation of the PPC metric (from Last Planner System practices) measures the proportion of planned agenda items completed during an ICE session. Informants emphasized that PPC is only meaningful when clear and measurable objectives are defined. When goals are not met, PPC data provides immediate feedback and supports corrective action planning in subsequent meetings. Key controllable factors influencing PPC include agenda quality, time management, and facilitator effectiveness.
- **Tool Usage Frequency:** Some informants reported tracking the use of technical tools such as BIM, GIS, or dashboards. While less consistently applied, these metrics provided insights into whether digital tools were meaningfully integrated into session workflows and helped identify areas for better technology adoption.
- **Meeting Participation:** Informants differed on the relevance of attendance tracking. While some considered it an important indicator of session quality and stakeholder commitment, others saw it as a superficial metric. The general consensus was that

ensuring relevant participants are present—those with decision-making authority—is more important than simply achieving high attendance rates.

Other Metrics Observed in ICE Sessions

As a continuation of Research Question 1, this subsection presents additional metrics that, while not directly tied to ICE session execution, still influence outcomes and are used in adjacent processes.

Informants described a range of supplementary metrics that shape the broader context in which ICE sessions take place:

- **Percentage Plan Complete (PPC):** This metric, central to Last Planner System (LPS) practices, was frequently reviewed at the start of ICE sessions to assess ongoing progress toward planned activities. Informants emphasized that an optimal PPC range (70–90%) encourages ambition without being unrealistic. Extremely high PPC values were sometimes viewed as a red flag, indicating overly conservative planning.
- **Root Cause Analysis:** When PPC targets were not met, informants often conducted systematic root cause analyses. Standardized categories—such as inadequate staffing or unclear task descriptions—enabled trend identification and targeted process improvements. This demonstrates how metrics can inform upstream planning, not just session performance.
- **BIM Metrics:** Metrics such as clash detection (number and resolution time of conflicts) and model maturity assessments (alignment between design progress and model completeness) were mentioned by some informants. However, integration of these metrics into ICE sessions varied widely, with some teams relying on them primarily at project-level reviews rather than within ICE workflows.

These supplementary metrics illustrate that ICE measurement is not isolated from the broader project context. Rather, effective use of metrics in ICE often depends on integration with upstream planning and digital model management practices.

ICE Measurements Not Regularly Used

This subsection highlights metrics that are recognized in literature but are rarely applied in practice, shedding light on the disconnect between theoretical ideals and on-the-ground implementation.

Informants identified several theoretically valuable metrics that are not commonly used in ICE sessions due to practical limitations, lack of resources, or unclear implementation strategies:

- *Decision Quality:* Metrics like "stickiness," assessing whether decisions remain sustainable over time, were seen as valuable but resource-intensive to track.
- *Cost Analysis:* Calculating the cost of ICE sessions versus alternative methods was viewed as unreliable and time-consuming, despite potential insights.
- *Time Use and Task Prioritization:* One informant identified the need to measure time spent on low-priority tasks but lacked an implementation strategy.
- *Response and Decision Latency:* Although discussed in literature, informants found it impractical to measure in dynamic ICE environments.

Main Challenges in Using Measurements in ICE Sessions (RQ-2)

This subsection addresses Research Question 2 by identifying key barriers practitioners encounter when applying metrics in ICE sessions, including organizational, cultural, and technical challenges.

While most informants viewed metrics as valuable tools, they also highlighted numerous obstacles that hinder effective measurement in practice. These challenges can be grouped into

two categories: general challenges related to the ICE environment, and specific challenges tied to the use and interpretation of metrics.

General Challenges with ICE sessions

- **Participants and Decision-Making Authority:** Several informants emphasized that poorly selected participants often limit the value of ICE sessions. Sessions sometimes include individuals without sufficient decision-making authority or technical knowledge, resulting in delays or unproductive discussions. In public-sector projects, for example, decisions are often deferred due to hierarchical approval processes. Overcrowded sessions with irrelevant stakeholders were also cited as reducing effectiveness.
- **Training and Knowledge Gaps:** Many participants lack foundational understanding of ICE and VDC methodologies, which weakens their ability to engage meaningfully with metrics and decision-making. Informants consistently stressed the need for structured onboarding and training to ensure alignment and competence from the outset.
- **Time Consumption:** ICE sessions, particularly those with poorly defined agendas, were perceived as time-consuming. Informants noted that sessions sometimes focus too much on tracking progress, leaving insufficient time for substantive discussion and problem-solving. Several participants also felt that the time investment required was not always proportional to their role in the project.
- **Logging Issues:** Informants reported that logging and documenting metrics is frequently deprioritized in high-pressure project environments. The use of multiple disconnected case management systems complicates the tracking process and leads to inconsistencies. This results in fragmented data, making it harder to follow up on agreed actions or analyse trends over time.

Challenges in the Use and Interpretation of Metrics

- **Defining Relevant Metrics:** A recurring theme was the lack of clarity around what should be measured. Some metrics were perceived as arbitrary or disconnected from project goals. Informants stressed the importance of focusing on actionable and goal-aligned measurements that produce long-term value rather than superficial data.
- **Underutilized Measurements:** Several informants expressed frustration that even when data is collected, it is rarely reviewed or used to inform decision-making. Metrics often become a procedural formality rather than a tool for improvement, leading to disengagement and diminished trust in the process.
- **Understanding and Relevance of Metrics:** Many participants reportedly struggled to interpret metrics meaningfully. Numbers were often presented without sufficient explanation, reducing their usefulness. Informants called for better communication and education around the intent and application of each metric.
- **Psychological Effects:** Some informants described a cultural resistance to measurement, particularly in Nordic project settings. Frequent monitoring was sometimes viewed as surveillance rather than support, which led to decreased openness and lower morale. Informants emphasized that framing metrics as tools for learning—not control—is essential for maintaining trust.
- **Survey Challenges:** End-of-session surveys were common but often affected by fatigue and response bias. Participants tended to provide socially desirable answers or skip responses entirely. Informants suggested that surveys be kept short (under 30 seconds), easy to complete, and designed with even-numbered rating scales to avoid neutral answers.

- **Technical Issues:** Informants cited system integration problems, manual data handling, and inconsistent technical competence as serious impediments to effective measurement. Without better digital tools and training, the reliability and usefulness of collected data remain limited.,

Collectively, these findings show that effective measurement in ICE sessions depends not only on metric selection but also on participant capability, organizational culture, and system infrastructure. These barriers must be addressed holistically to unlock the full value of metrics in practice.

HOW SHOULD MEASUREMENTS BE USED IN FUTURE ICE SESSIONS (RQ-3)?

This subsection addresses Research Question 3 by presenting informants' suggestions and strategies for improving the application of metrics in ICE sessions moving forward.

Building on the challenges identified, informants proposed several targeted improvements to help realize the full potential of measurement systems in ICE environments. These recommendations reflect both practical experience and a desire for more integrated, transparent, and adaptive approaches.

- **Automate the Measurement Process:** Many informants advocated greater automation in metric collection and reporting. Manual data logging was described as both error-prone and inefficient. Improved integration between digital platforms—such as BIM tools, dashboards, and project management systems—was seen as essential for streamlining workflows and reducing data loss. Automation would also free up time for interpretation and action.
- **Standardization of Metrics and Protocols:** Informants called for the development of standardized measurement protocols across projects and organizations. Standard definitions, consistent indicators, and shared templates were seen as critical for enabling comparability and tracking trends over time. Some suggested that an industry-level standard—or even a national guideline—could help unify practice and reduce ambiguity in what and how to measure.
- **Improved Sharing Culture:** A more open culture of data sharing across teams and departments was widely emphasized. Informants argued that metrics should not be siloed within individual projects but used to build institutional knowledge. Sharing successes, failures, and lessons learned can foster continuous improvement and accelerate organizational learning.

  Continuous Evaluation and Adjustment: Several informants noted that metrics can quickly become outdated or irrelevant if not regularly reviewed. They recommended establishing periodic checkpoints to assess whether current metrics still reflect project goals and practical needs. This ensures that measurement systems remain dynamic and aligned with evolving priorities.
- **Practical Implementation Support:** Some informants highlighted the need for more applied guidance on VDC and ICE measurement implementation. Existing literature was seen as too abstract or academic. There were calls for practitioner-oriented tools such as checklists, templates, and practical handbooks that translate theoretical concepts into usable formats.

Together, these suggestions illustrate a strong practitioner appetite for more effective, accessible, and adaptive metric systems.

DISCUSSION

This study set out to examine the current use of measurements in ICE sessions, the challenges that hinder their effectiveness, and potential strategies for improvement. The findings reinforce the central role of metrics in VDC and ICE literature (Kunz & Fischer, 2012; Rischmoller et al., 2018), but also reveal a persistent and significant gap between theoretical frameworks and practical implementation. In this section, the findings are interpreted in relation to existing research and the three guiding research questions, with emphasis on both theoretical and practical implications.

CURRENT USE OF MEASUREMENTS IN ICE SESSIONS

The findings support earlier studies (e.g., Belsvik et al., 2019; Kunz & Fischer, 2020) by confirming that practitioners regard metrics as essential for guiding continuous improvement and enabling collaborative decision-making. Consistent with prior research, metrics such as PPC of sessions, meeting evaluation surveys, and tool usage frequency were among the most commonly applied. These align with the broader VDC literature, which advocates structured measurement as a means of promoting transparency, alignment, and accountability (Rischmoller et al., 2018).

However, this study contributes a more nuanced picture by showing that the actual scope of metrics used in practice is narrower than what theory recommends. While Kunz and Fischer (2012) and Belsvik et al. (2019) propose broader sets of indicators—including decision stickiness, meeting costs, and response latency—these are rarely used in practice. This finding highlights an important theoretical insight: metric adoption in ICE sessions is shaped less by methodological idealism and more by perceived utility and resource constraints in real-world settings.

This suggests that existing literature tends to overestimate the practical feasibility of comprehensive metric systems. The contribution here is a more grounded understanding of which metrics practitioners prioritize, and why. This complements prior theoretical work by clarifying which measurement practices are sustainable and scalable in project environments, and which remain largely aspirational.

CHALLENGES ASSOCIATED WITH USING MEASUREMENTS

The study also affirms and expands on existing research regarding the barriers to effective measurement use. Consistent with Fosse & Ballard (2016) and Del Savio et al. (2022), participants emphasized the importance of including relevant decision-makers in ICE sessions. However, the findings deepen this insight by highlighting how insufficient decision authority and misaligned participant roles actively undermine the potential of ICE's low-latency collaboration environment.

A key theoretical contribution lies in the differentiation between technical measurement issues (e.g., system integration and data logging) and behavioral and organizational barriers (e.g., metric fatigue, perceived irrelevance, or surveillance anxiety). Prior literature (e.g., Fischer et al., 2017; Khanzode, 2011) has touched on these dimensions, but this study provides empirical evidence of how cultural factors—particularly in Nordic contexts—affect metric acceptance and application. This suggests the need for a more context-sensitive approach to metric design and implementation than previously assumed in the literature.

The issue of underutilized data further reinforces Kunz and Fischer's (2012) observation that the challenge is not only in collecting data, but in ensuring meaningful use of metrics to drive action. When metrics are seen as administrative rather than actionable, they lose their strategic value. This echoes concerns raised by Majumdar et al. (2022) but provides a more detailed explanation of why this disconnect persists and how it impacts trust, engagement, and learning.

THEORETICAL AND PRACTICAL CONTRIBUTIONS

This study contributes to theory by clarifying the boundary between theoretically desirable and practically usable ICE metrics. It calls for a recalibration of academic frameworks to reflect what is realistically implementable in project environments. It also proposes a conceptual distinction between "formal metrics" (those captured and reported) and "functional metrics" (those actually used to inform decisions)—a distinction that future research can further develop.

Practically, the findings lead to several concrete recommendations for improving metric use in ICE sessions:

- Automate data collection and logging to reduce manual effort and improve reliability.
- Standardize core metrics across projects and organizations to improve comparability and reduce ambiguity.
- Foster a transparent, data-sharing culture, where metrics are used not just for reporting, but for reflection and learning.
- Regularly review and adjust metrics to ensure continued relevance and alignment with evolving project goals.

These align closely with PDCA principles and Lean Construction thinking, reinforcing the idea that metrics should support continuous learning and system-level improvement, not just performance monitoring.

CONCLUSION

This study investigated the use of metrics in Integrated Concurrent Engineering (ICE) sessions, identified key challenges in their application, and proposed strategies for more effective integration within Virtual Design and Construction (VDC) practice. The findings confirm the critical role of metrics in supporting continuous improvement, collaborative decision-making, and project alignment. However, a clear implementation gap persists between theoretical best practices and the realities of day-to-day project work, where practitioners often encounter barriers related to participant selection, underutilized or poorly defined metrics, and technological or cultural constraints.

Based on the findings, several practical recommendations are offered: automate data collection and reporting to reduce manual effort and improve data reliability; standardize core metrics across projects and organizations to ensure clarity and comparability; foster a transparent data-sharing culture to support cross-project learning; regularly review and adjust measurement practices to maintain relevance; and improve participant training and preparation to enhance engagement and accountability. These recommendations are immediately applicable for project managers, VDC coordinators, and organizational leaders aiming to improve project performance and support a culture of continuous improvement.

While the study provides valuable insight, it is limited by its small and purposive sample of eight experts, and the qualitative nature of the data does not allow for generalization or causal inference. Future research should expand the sample size and diversity to include a broader range of industry roles and project contexts. Quantitative studies are needed to link specific ICE metrics to project outcomes such as cost, schedule, and stakeholder satisfaction. Longitudinal research could also explore how metric use evolves across project phases, while studies on organizational and cultural factors—such as trust, perceived surveillance, and motivation—could deepen understanding of how to sustain engagement with measurement practices. Finally, the development and testing of practical implementation frameworks or toolkits could help bridge the gap between theory and practice, advancing both academic and industry knowledge on effective metric use in ICE sessions.

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