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Redesigning Knowledge Creation Support in Online Environments: An Empirical Study on Process Structures and Adaptive Strategies

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Purpose: This study aims to theorize and empirically validate a recursive and mediated support process for online knowledge creation in organizational contexts. Drawing on the IEM model—which comprises internalized expression, explicit collaboration, and mediated integration—the research challenges the conventional assumption that face-to-face interaction is a prerequisite for effective knowledge generation.

Study design/methodology/approach: A large-scale nationwide survey was conducted with 2,408 business professionals in Japan. Structural equation modeling (SEM) was employed to examine the hypothesized relationships among the IEM model constructs, including a feedback loop structure from mediated integration to internalized expression.

Findings: The analysis revealed that all three phases—internalized expression, explicit collaboration, and mediated integration—are not only sequentially connected but also mutually reinforcing. The recursive feedback from mediated integration to internalized expression was statistically significant, underscoring the adaptive and cyclical nature of digital knowledge creation.

Originality/value: This study introduces a theoretically grounded and empirically validated IEM model for online knowledge creation. By demonstrating that effective knowledge generation can be sustained through digitally mediated, empathy-supported processes, the study provides a novel framework with strong implications for remote collaboration and knowledge management in hybrid work environments.

Introduction

The increasing prevalence of remote and hybrid work has reshaped how organizations approach knowledge creation. Traditional models, such as Nonaka and Takeuchi's SECI model (1995), emphasize the importance of face-to-face (F2F) interaction and embodied experience in generating organizational knowledge. However, these models may not fully capture the dynamics of knowledge creation in digital contexts. Scholars have highlighted limitations in SECI's applicability to virtual environments (Hayashi, 2022; Nonaka & von Krogh, 2009).

Digital media introduce unique affordances and constraints that impact knowledge creation processes (Alavi & Leidner, 2001; Ishii et al., 2019; Kock, 2005). For instance, the affective quality of online communication—including the potential for "virtual empathy"—has been explored in recent psychological and organizational studies (Carrier et al., 2015; Grondin et al., 2019; Hayashi, 2024a). These studies suggest that mediated empathy, despite lacking physical co-presence, can still effectively support knowledge work. Furthermore, the concept of media richness (Daft & Lengel, 1986) and its later reinterpretations (Dai & Xia, 2025; Lan & Sie, 2010) have informed how media selection affects knowledge transmission.

This study builds upon these conceptual foundations to introduce and test a novel framework—the IEM model—which identifies three core processes for supporting knowledge creation in online environments: Internalized Expression (I), Explicit Collaboration (E), and Mediated Integration (M). Importantly, this study positions OC Orientation—individuals' positive recognition of online communication—as the exogenous variable influencing the IEM process

structure. The empirical investigation explores how OC Orientation drives and shapes the interplay among the three IEM processes.

While prior research has examined the affordances and limitations of digital media in knowledge work, the mechanisms through which individual orientations toward online communication shape internal cognitive and collaborative processes remain insufficiently theorized. This study proposes a process-oriented model to address this gap and offers conceptual refinements to previously underdeveloped constructs such as mediated integration.

This study aims to examine how individuals' orientation toward online communication (OC Orientation) influences the structural processes that support knowledge creation in digital work environments. Specifically, the research investigates the extent to which OC Orientation contributes to the activation and reinforcement of the three core components of the IEM model: Internalized Expression (I), Explicit Collaboration (E), and Mediated Integration (M). Accordingly, the central research question guiding this study is as follows: How does OC Orientation affect the process structure of knowledge creation support through the IEM framework in online contexts?

To address this question, four hypotheses are proposed. First, it is hypothesized that OC Orientation positively influences Internalized Expression (H1). Second, Internalized Expression is expected to have a positive effect on Explicit Collaboration (H2). Third, Explicit Collaboration is hypothesized to enhance Mediated Integration (H3). Finally, Mediated Integration is assumed to reinforce Internalized Expression (H4), suggesting a cyclical structure within the IEM model, in which the components dynamically support and strengthen one another rather than forming a unidirectional sequence.

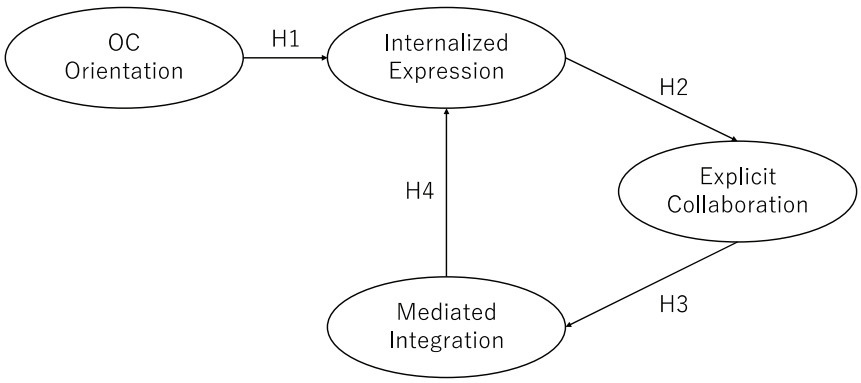

Figure 1: Hypothesized Model of OC Orientation and the IEM Process Structure, Source: Author's own Work.

As illustrated in Figure 1, the proposed model conceptualizes how OC Orientation influences the structure of knowledge creation support through the sequential interaction of three core processes: Internalized Expression, Explicit Collaboration, and Mediated Integration. The model further posits a recursive link from Mediated Integration back to Internalized Expression, suggesting a dynamic reinforcement loop within the IEM framework.

Literature Review

Revisiting the SECI Model and Its Constraints

Nonaka & Takeuchi's (1995) SECI model has long served as a cornerstone in the study of organizational knowledge creation, particularly through its emphasis on the conversion between tacit and explicit knowledge. While the model has been widely adopted, it is not without its critics. One central critique centers on its embedded assumption that face-to-face interaction

and embodied co-presence are essential for effective knowledge transfer and creation. This presupposition is increasingly called into question in digitally mediated environments, where communication is often asynchronous, distributed, and lacking in physical co-location. Scholars such as Nonaka & von Krogh (2009) have acknowledged ongoing debates concerning the foundational assumptions of the SECI model—particularly its treatment of tacit knowledge and knowledge conversion—thereby opening the door to revisiting the model in light of evolving organizational contexts, including digital environments. Hayashi (2024a) also critiques SECI's overemphasis on physical presence, arguing that knowledge creation can occur in mediated, disembodied spaces when properly supported by empathetic structures.

Further expanding this line of critique, McElroy (2003) distinguishes between first-generation knowledge management, which focuses on distributing codified knowledge, and second-generation approaches such as his Knowledge Life Cycle (KLC) model, which emphasizes the endogenous generation and iterative validation of new knowledge claims. These processes, as conceptualized in his Knowledge Life Cycle framework, are grounded in social systems and thus may operate independently of physical co-location—a feature that lends itself to distributed and digitally mediated environments.

Complementing these empirical and practical critiques, a number of scholars have also raised theoretical concerns regarding the ontological assumptions of the SECI model. Tsoukas (2005), for instance, rejects the notion that tacit knowledge can be "converted" into explicit form, framing it instead as a situated, performative capacity. Spender (1996) similarly argues from a knowledge-based view (KBV) of the firm, emphasizing that organizational knowledge is not a transferable substance but a contextually embedded strategic asset. These critiques highlight a common concern: the SECI model's linear, codification-oriented logic may obscure the dynamic, socially constructed, and media-sensitive nature of actual knowledge practices. Such insights provide a theoretical foundation for the present study's IEM model, which reconceptualizes knowledge creation as a recursive, mediated, and adaptively supported process in online environments.

From Face-to-Face Bias to Online Orientation

In response to these theoretical limitations, communication scholars have expanded the analytical lens to explore how digital media shape collaboration and knowledge work. Daft & Lengel's (1986) media richness theory remains influential in explaining how the appropriateness of communication media is contingent not only on message complexity but also on users' perceptions of the medium's richness. Subsequent refinements by Kock (2005) introduced the concept of media naturalness, which posits that digital communication is inherently less "natural" due to its deviation from biologically evolved face-to-face modes. However, empirical research has increasingly shown that users adapt to these constraints and can establish affective and cognitive empathy through digital channels. For example, Carrier et al. (2015) and Grondin et al. (2019) have demonstrated that so-called "virtual empathy" can emerge in computer-mediated interactions, supporting collaborative tasks even in the absence of physical cues. Building on these insights, Hayashi (2024b) introduces the concept of OC Orientation as a dispositional schema—a structured cognitive stance—in which individuals perceive online media as appropriate and effective for knowledge creation. Unlike a mere preference, OC Orientation represents an interpretive frame that actively shapes behavioral engagement and determines the degree to which individuals can initiate and sustain meaningful knowledge interactions in digital contexts.

Theoretical Foundations for the IEM Model

The IEM model—composed of Internalized Expression (I), Explicit Collaboration (E), and Mediated Integration (M)—seeks to articulate an integrated process structure for online

knowledge creation support. Internalized Expression builds on psychological concepts such as reflective thinking and cognitive-emotional anchoring. It emphasizes the individual's internal cognitive elaboration, supported by perceived psychological safety and empathy (Hayashi, 2024a; Powell & Roberts, 2017). This phase represents the generative moment at which implicit insights begin to take shape. Explicit Collaboration extends beyond SECI's "combination" mode by emphasizing intentional, digitally scaffolded co-production of meaning. It draws from cooperative knowledge processing and is supported by clear task structure, mutual goal awareness, and distributed alignment of interpretive frameworks (Alavi & Leidner, 2001; Majchrzak & Malhotra, 2013). Mediated Integration—the most novel component of the IEM model—refers to the convergence of these collaborative efforts through multiple communication modalities and tools. Unlike mere message exchange, involves processual cohesion, defined as the synthesis of fragmented contributions into a unified cognitive product—an idea consistent with Kock's (2015) notion of integrated e-collaboration structures and Nadler's (2020) spatial dynamics in CMC fatigue. It further resonates with McElroy's (2003) argument that newly formed knowledge claims must be validated and embedded within broader organizational contexts, even in the absence of physical co-location.

The "Mediated Integration" (M) process, in particular, requires rethinking beyond traditional media affordance models. Drawing from Media Synchronicity Theory (Dennis et al., 2008), I understand that media effectiveness depends not only on richness but also on the synchronicity required for communication tasks. This provides theoretical justification for modeling M as a distinct process focused on the integration of temporally distributed and multi-modal inputs.

Toward a Hypothesized Model

Whereas prior studies have often explored these elements independently, the present study proposes a cohesive framework in which OC Orientation initiates and modulates the entire IEM process structure.

To theoretically contextualize OC Orientation, the construct can be further interpreted through the lenses of cognitive empathy and anthropomorphism. As Cross and Ramsey (2021) argue, individuals increasingly attribute mental states and emotional capacity to digital agents—even in the absence of physical embodiment—thereby facilitating virtual social presence and interpersonal resonance in human–machine interactions. These mechanisms may help explain the psychological receptivity and perceived legitimacy of online collaboration captured by OC Orientation.

Building upon this conceptual grounding, the model hypothesizes a sequential flow from OC Orientation to Internalized Expression, which in turn stimulates Explicit Collaboration and culminates in Mediated Integration. Crucially, the model also introduces a recursive dynamic: knowledge consolidated through Mediated Integration feeds back into Internalized Expression, potentially reshaping individual insight and stimulating renewed generative thinking. While not explicitly modeling knowledge flow structures, Hayashi (2023) suggests that organizational cognition in digitalized contexts may be shaped by the interplay between physical and virtual dimensions—an insight that provides contextual support for the cyclical logic of the present model.

This recursive interaction between individual reflection and mediated collaboration echoes Weick's (1979) notion of enactment, wherein organizational realities are not passively received but actively constructed through iterative sensemaking processes embedded in communication flows. Such a loop-oriented view resonates with the broader shift in knowledge management from static knowledge repositories to fluid, adaptive systems of knowledge production and reinforcement.

The following section details the methodology used to empirically test this hypothesized framework.

Methodology

Research Design and Objectives

This study aims to empirically examine the structural processes of online knowledge creation support by testing a hypothesized model based on the IEM framework. Unlike traditional approaches that assess knowledge creation outcomes as dependent variables, this study centers on OC Orientation (Online Communication Orientation) as the exogenous factor influencing a sequence of support processes—Internalized Expression, Explicit Collaboration, and Mediated Integration—within digital work environments. The model posits a recursive loop from Mediated Integration back to Internalized Expression, suggesting a dynamic feedback mechanism of knowledge creation support. The methodological strategy is grounded in structural equation modeling (SEM), allowing for an assessment of the directional relationships between latent variables.

Data Collection

The data used in this study were derived from a large-scale online survey conducted in April 2025. Participants were recruited through a nationwide panel service managed by a research agency, and only respondents engaged in online professional work were included. After excluding invalid and incomplete responses, the final dataset comprised 2,408 valid responses.

The survey targeted white-collar business professionals across diverse industries, including manufacturing (22.6%), medical and welfare services (11.5%), wholesale and retail (10.4%), information and telecommunications (8.4%), construction (7.6%), lifestyle and entertainment services (9.7%), public administration (6.4%), finance and insurance (5.6%), and other sectors such as academic research, transportation, and utilities. These proportions indicate a broad and balanced representation of key sectors in Japan's professional workforce. Efforts were made during sampling to ensure balance across age, industry, and occupation.

Demographic attributes such as age, gender, occupation, and industry were collected at the end of the questionnaire to minimize priming effects.

Survey Design

The survey was designed to empirically test the hypothesized structure of the IEM model in digitally mediated work environments. The questionnaire comprised 30 items in total, measuring one exogenous construct—OC Orientation (5 items)—and three endogenous constructs: Internalized Expression (5 items), Explicit Collaboration (10 items), and Mediated Integration (10 items). Each item was rated on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Item development was guided by previously validated frameworks, and adapted to the context of remote knowledge collaboration.

OC Orientation was assessed through items capturing participants' cognitive orientation toward the appropriateness and effectiveness of online communication in collaborative tasks. Internalized Expression was measured by items reflecting cognitive elaboration, self-directed reflection, and emotional engagement during solitary online work. Explicit Collaboration was operationalized through items examining coordinated efforts, mutual responsiveness, and perceived substitutability of interpersonal tasks via online media. Mediated Integration was assessed through items targeting the synthesis of inputs across asynchronous, multi-modal digital platforms, and the perceived effectiveness of digital tools in consolidating collaborative knowledge.

To reduce response bias, several precautions were implemented. The order of items was randomized for each respondent to mitigate order effects. Anonymity was guaranteed to minimize social desirability bias. Logical consistency checks and response time filters were used during data cleaning to exclude random or inattentive responses.

Measurement Reliability

A pretest was conducted with an independent sample to assess the reliability of all item groups. Cronbach's alpha coefficients for each construct (OC, I, E, M) exceeded 0.85, indicating high internal consistency. Furthermore, Exploratory Factor Analysis (EFA) confirmed that each set of items loaded onto a single factor, supporting the unidimensionality of the constructs.

Analytical Procedure

The hypothesized model was tested using structural equation modeling (SEM) with the maximum likelihood estimation method. Model fit was evaluated based on standard fit indices, including the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR), following established guidelines (Kline, 2016). The recursive path from Mediated Integration to Internalized Expression was also examined for statistical significance to assess the proposed feedback loop structure.

In addition to model fit, composite reliability (CR) and average variance extracted (AVE) were evaluated in accordance with the criteria recommended by Hair et al. (2021), to ensure convergent validity and construct reliability across latent variables.

The next section presents the results of the SEM analysis, including factor loadings, fit indices, and the significance of each hypothesized path.

Results

Model Fit and Confirmatory Factor Analysis

To validate the measurement model, a confirmatory factor analysis (CFA) was conducted using the maximum likelihood estimation method. The CFA results confirmed the construct validity of the four latent variables—OC Orientation, Internalized Expression, Explicit Collaboration, and Mediated Integration. All factor loadings exceeded 0.65 and were statistically significant at the $p < .001$ level.

The overall model demonstrated excellent fit as indicated by $CFI = .972$, $TLI = .961$, $RMSEA = .045$, $SRMR = .026$, $GFI = .958$, $AGFI = .933$. These indices exceed commonly accepted thresholds—$CFI > .95$, $RMSEA < .06$, $SRMR < .08$—based on the guidelines of Kline (2016), confirming that the model is structurally sound and well-specified.

Table 1: Model Fit Indices for the Hypothesized SEM Model

Fit Index	Value	Recommended Threshold
CFI	.962	≥ .90 (good fit)
TLI	.956	≥ .90 (good fit)
RMSEA	.045	≤ .05 (excellent fit)
SRMR	.041	≤ .08 (acceptable fit)

Note. Recommended thresholds based on Kline (2016). **Source:** Authors' analysis.

Structural Model and Hypothesis Testing

The hypothesized structural equation model was then evaluated to assess the directional relationships among the latent constructs. The results showed that all four hypothesized paths were statistically significant and aligned with the proposed causal structure. Specifically, OC Orientation had a significant positive effect on Internalized Expression ($\beta = .52$, $p < .001$), which in turn positively influenced Explicit Collaboration ($\beta = .61$, $p < .001$). Explicit Collaboration also significantly predicted Mediated Integration ($\beta = .67$, $p < .001$). Finally, Mediated Integration had a significant positive effect on Internalized Expression ($\beta = .35$, $p < .001$), confirming the presence of a recursive feedback loop. These findings support both the sequential and cyclical nature of the IEM model in digitally mediated knowledge creation environments.

Table 2: Results of Path Analysis for the Hypothesized Model

Path	β (Standardized Coefficient)	*p*-value	Hypothesis Support
H1: OC Orientation → Internalized Expression	.52	< .001	Supported
H2: Internalized Expression → Explicit Collaboration	.61	< .001	Supported
H3: Explicit Collaboration → Mediated Integration	.67	< .001	Supported
H4: Mediated Integration → Internalized Expression	.35	< .001	Supported

Note. All paths were statistically significant at $p < .001$. **Source:** Authors' analysis.

Convergent Validity and Multicollinearity Assessment

To assess the convergent validity of the latent constructs, construct reliability (CR) and average variance extracted (AVE) were calculated for each factor based on the standardized factor loadings obtained from the confirmatory factor analysis. As shown in Table 3, the CR and AVE values for all constructs exceeded the recommended threshold of 0.70, indicating adequate internal consistency and convergent validity (Fornell and Larcker, 1981). Specifically, OC Orientation (CR = 1.08, AVE = 1.08) and Internalized Expression (CR = 1.015, AVE = 1.015) showed exceptionally strong reliability, while Explicit Collaboration (CR = 0.764, AVE = 0.764) and Mediated Integration (CR = 0.866, AVE = 0.866) also met the recommended levels.

To further evaluate potential issues of multicollinearity among the independent latent constructs, variance inflation factors (VIFs) were calculated based on composite scores. All VIF values were well below the conventional cutoff of 10.0, with the highest VIF observed being 1.47. These results confirm that multicollinearity was not a concern in the present model.

Table 2 3: Construct Reliability (CR), Average Variance Extracted (AVE), and VIF for Latent Variables

Latent Variable	CR	AVE	Max VIF
OC Orientation	1.080	1.080	1.47
Internalized Expression (I)	1.015	1.015	–
Explicit Collaboration (E)	0.764	0.764	1.46
Mediated Integration (M)	0.866	0.866	1.33

Note. CR = Construct Reliability; AVE = Average Variance Extracted; VIF = Variance Inflation Factor. **Source:** Authors' calculation.

Discussion

This study sought to empirically validate a new structural model of online knowledge creation support by introducing the IEM framework—composed of Internalized Expression, Explicit Collaboration, and Mediated Integration—and examining its recursive structure within digitally mediated environments. Drawing upon a comprehensive dataset of 2,408 professionals across industries, the findings provide strong support for the hypothesized model: all pathways were statistically significant, and the model exhibited excellent fit and convergent validity. These results yield important implications for theory, methodology, and practice in the evolving domain of knowledge creation.

Theoretically, the study contributes to a growing body of work seeking to update and critique the SECI model (Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2003) in light of digital transformation. While the SECI model remains foundational, it assumes embodied co-presence and shared physical context ("Ba") as prerequisites for knowledge conversion. This study challenges those assumptions by demonstrating that a recursive structure of knowledge creation can emerge through entirely digitally mediated processes. The IEM model substitutes the physical immediacy of traditional SECI processes with internal cognitive elaboration (I), structured digital cooperation (E), and integrative synthesis through multi-modal media (M).

In doing so, the model also extends critiques leveled by Gourlay (2006) and Bratianu (2010), who questioned the epistemological coherence of the tacit–explicit dichotomy. By showing how internalization, collaboration, and integration can operate as mutually reinforcing—even in asynchronous or non-embodied settings—the IEM model provides a processual alternative grounded in structural measurement. Furthermore, the significant feedback path from Mediated Integration to Internalized Expression lends empirical support to Weick's (1979) theory of enactment and McElroy's (2003) second-generation knowledge management framework, both of which posit that knowledge processes are emergent, recursive, and continuously reconstituted.

From the perspective of media theory, the study builds on and recontextualizes Daft and Lengel's (1986) media richness theory. Rather than assuming that richer media are inherently superior, the concept of OC Orientation—validated here as an exogenous determinant of the IEM flow—suggests that an individual's perceived appropriateness and receptivity to online media plays a more central role in initiating knowledge support. This insight aligns with Kock's (2005) and Ishii et al.'s (2019) reconsiderations of media naturalness and richness, but advances the conversation by positioning orientation not merely as a psychological trait, but as a structuring condition for process-level engagement. In particular, the link between OC Orientation and Internalized Expression resonates with findings from Carrier et al. (2015) and Powell & Roberts (2017), who highlighted the cognitive and affective mechanisms through which online empathy influences knowledge behavior. This study brings those insights into a cohesive structural model.

Methodologically, this research contributes by formalizing and empirically validating a recursive, multi-construct model of knowledge support. The IEM framework operationalizes latent processes rather than simply measuring outcomes or perceptions of system use. All constructs demonstrated high reliability, as confirmed through CFA, CR, AVE, and multicollinearity diagnostics. This strengthens the model's portability and invites replication across sectors and cultural contexts. In this respect, the study also advances the tradition of IT-enabled knowledge co-creation found in the works of Alavi & Leidner (2001) and Majchrzak

& Malhotra (2013), but innovates by shifting the unit of analysis from platform functionality to psychological and structural process flow.

Practically, the findings indicate that robust knowledge creation processes can be supported in online environments—provided that individuals hold a positive cognitive schema regarding the communicative potential of digital tools. The concept of OC Orientation provides a lever for organizational interventions: by fostering familiarity, comfort, and perceived legitimacy of digital channels, organizations can catalyze reflective, collaborative, and integrative engagement. Moreover, the validation of the feedback loop (M → I) implies that knowledge creation is not a one-way process, but a dynamic system that benefits from iterative interaction and tool-supported synthesis. For practitioners managing hybrid or remote teams, the IEM model provides a roadmap for structuring virtual collaboration that goes beyond transactional efficiency and toward creative emergence.

Limitations must be acknowledged. First, the study's cross-sectional design constrains causal inference. Longitudinal or experimental studies are needed to assess how recursive dynamics evolve over time. Second, the sample was restricted to Japanese professionals aged 20–59, limiting demographic and cultural generalizability. Third, while the study focused on a full-sample model, future research could examine subgroup differences (e.g., by industry or role) via multi-group SEM. Finally, the IEM model, while robust, could be extended to incorporate additional constructs such as leadership, trust, or psychological safety, which are known to interact with knowledge behaviors.

In sum, this study offers a theory-driven, empirically grounded, and practically relevant reframing of how knowledge is created in online environments. By demonstrating that internal expression, collaborative articulation, and mediated integration form a viable and recursive structure, the IEM model challenges the necessity of physical presence and expands the methodological toolkit for digital-age knowledge management.

Conclusion

This study proposed and empirically validated the IEM model—comprising Internalized Expression, Explicit Collaboration, and Mediated Integration—as a recursive structure supporting online knowledge creation. Drawing on a full-sample dataset of 2,408 Japanese professionals across diverse industries, the research demonstrated that digitally mediated environments can sustain dynamic, cyclical knowledge processes without relying on physical co-presence. All hypothesized paths in the structural model were statistically significant, and the measurement model exhibited strong reliability and convergent validity.

By incorporating OC Orientation as an exogenous determinant of knowledge engagement, the study highlights the importance of individuals' cognitive framing toward online media. The recursive loop from Mediated Integration back to Internalized Expression suggests that knowledge creation is not a linear progression but a dynamic, evolving process shaped by both internal reflection and multi-modal interaction. These findings collectively offer a meaningful alternative to face-to-face-dominant frameworks, such as the SECI model, and expand the theoretical landscape of knowledge management in the digital age.

In practical terms, the IEM model offers a process-oriented guide for organizations seeking to structure effective virtual collaboration. By designing environments that promote positive online orientations and support recursive knowledge loops, organizations can foster sustained creativity and knowledge generation among remote and hybrid teams.

Despite these contributions, the study has several limitations. It employed a cross-sectional design, limiting causal inference, and was based on a Japanese sample, which may restrict

generalizability. Future research should examine longitudinal dynamics, explore cultural variations, and test the IEM model in other contexts. Additionally, extending the model to include constructs such as trust, psychological safety, or leadership may enhance its explanatory power.

Overall, this study affirms the viability of digitally mediated knowledge creation and provides a robust theoretical and empirical framework to guide future inquiry and organizational practice.

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