



A Study on the Challenges of Knowledge Externalization in Small-Scale Research Projects

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Abstract. Knowledge management in small-scale research projects faces a difficult-to-resolve contradiction. Knowledge creation in such projects relies heavily on individual experience and intuition; however, precisely because of their small scale and short duration, there is insufficient institutional support to transform this individual knowledge into organizational capital. This paper employs the concept of “institutional density” to analyze this issue. By comparing three scenarios — large-scale projects, routine operations, and small-scale projects — We find that small-scale projects represent a virtual institutional vacuum when it comes to knowledge externalization. By tracking a DNS resolution simulation project, We identified four points where knowledge flow is blocked. We also used the theoretical framework of exploration and exploitation to explain why this institutional mismatch occurs. Finally, We propose that in environments with low institutional density, knowledge management should not rely on coercion but rather on cognitive triggers. This idea offers a practical approach to managing knowledge in exploratory activities.

Keywords: Institutional density; Knowledge externalization; Small-scale research projects; Exploratory activities; Cognitive triggers.

1 Introduction

Once a research project is completed, what remains besides the technical report and the paper? Where does the knowledge generated during the process go? For example, why was one parameter chosen over another? What detours were taken during modeling? And under what criteria were the final conclusions reached? This knowledge is often more valuable than the final results, yet it frequently vanishes once the project ends. This problem exists in various research institutions, but it is particularly severe in small and micro-scale independent research projects.

Why is this particularly severe in small and micro-scale projects? Because such projects have limited funding—typically only a few tens of thousands of yuan—and small teams, with perhaps only one or two people actually doing the work. After the project is completed, the technical report is submitted and the paper is published, but the trial-and-error experiences, the rationale behind decisions, and the logic behind

parameter adjustments are largely confined to the minds of those who carried out the work. Once people leave, or as time passes, this knowledge is lost. The next person undertaking a similar project must start from scratch, repeating the same mistakes that were made before. This is actually a significant waste, though it often goes unnoticed because what is being wasted is process knowledge — not something that directly appears on the balance sheet.

Interestingly, research shows that the larger the project, the easier it is to implement knowledge management. Large projects involve many people and tasks, necessitating meetings, meeting minutes, and document management systems — structures that compel people to document their knowledge. Small projects are different. Communication in small projects relies on verbal exchanges, and work is done through tacit understanding; there are few formal requirements to document anything. As a result, it is difficult for individual knowledge to be transformed into organizational knowledge. Research indicates that small and medium-sized R&D teams invest very little in knowledge management and organizational learning, relying primarily on individual experience and informal exchanges, with a lack of formal knowledge management processes^[1].

From the perspective of classic knowledge management theory, much of an organization's valuable knowledge resides in the minds of individuals. If there is no way to extract and document it, that knowledge disappears when the person leaves. Traditional research management focuses on whether funds have been fully spent and reports have been submitted, paying little attention to whether the tacit knowledge generated during the process has been documented. This creates a fundamental contradiction: knowledge production in small-scale projects relies heavily on individual tacit knowledge, yet precisely because these projects are “small,” there is a lack of institutional mechanisms to transform this individual knowledge into organizational knowledge. The core of the problem is not that people are unwilling to share, but that the organization has failed to provide appropriate channels for doing so.

2 Theoretical Foundation and Analytical Framework

2.1 Theoretical Foundation and Analytical Framework

Ikujiro Nonaka's SECI model is a classic framework for understanding knowledge creation in organizations. It divides knowledge creation into four stages: socialization (tacit to tacit), externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit). The externalization stage involves transforming ideas in an individual's mind into text or diagrams that can be communicated and preserved. This step is both the most critical and the most vulnerable.

However, the SECI model contains an unstated premise: that the organization already possesses institutional mechanisms to support externalization. The model describes the four stages of knowledge transformation but does not specify the conditions under which these stages occur. Research indicates that knowledge externalization requires three conditions: the individual's willingness to express, the

availability of tools for expression, and institutional encouragement of expression. Among these three conditions, institutional support is central. Institutions can transform reluctance into willingness and provide the tools for expression ^[2]. In other words, if an activity is supported by a comprehensive institutional framework, knowledge externalization occurs naturally; if such a framework is absent, externalization relies entirely on individual initiative, making it highly unlikely to occur.

Here, it is worth elaborating on what constitutes an “institution.” Institutions do not necessarily have to be complex regulations; sometimes they are simply a template, a process, or a customary practice. For example, requiring an operations and maintenance team to write an incident report after resolving a fault is an institution. This institution is not complex, but its role is to make documenting the fault resolution process an integral part of the job, rather than an extra task. With this institution in place, knowledge externalization is embedded within the work itself. The problem with small-scale research projects is that, from project initiation to completion, there is virtually no stage where such institutional arrangements exist.

2.2 The Concept of Institutional Density and Its Analytical Dimensions

This paper introduces the concept of “institutional density” to address the following question: Why is knowledge externalization easy in some contexts but difficult in others?

Institutional density refers to the degree to which an organization has institutionalized knowledge externalization behaviors within a specific activity context. Specifically, it examines three aspects: whether there are formal rules requiring you to document information, whether there are process templates to assist you in documenting, and whether there are incentives to encourage you to document. The combined intensity of these three elements constitutes institutional density.

The role of institutional density is to reduce the initial costs of knowledge externalization. When institutional density is high, externalization is embedded within workflows; you do not need to consider “whether to record,” “what to record,” or “how to record” — the system has already made these decisions for you. When institutional density is low, externalization becomes an additional task that you must initiate, design, and execute yourself. When time is tight, such tasks are inevitably pushed to the bottom of the priority list.

The value of this concept lies in shifting the focus of knowledge externalization from an issue of individual responsibility to one of organizational design. In the past, we often assumed that knowledge wasn’t preserved because individuals were unwilling to write or share. However, from the perspective of institutional density, the problem may be that the organization hasn’t created the right conditions for such sharing. Institutional density varies across different scenarios, and the difficulty of knowledge externalization naturally varies as well.

2.3 Comparison of Institutional Density Across Three Scenarios

When applying the concept of institutional density to the actual operations of research institutions, the differences among the three scenarios become clear.

Large projects have a very high institutional density. Project proposals must be written at the outset, mid-term reports must be submitted, and documentation must be compiled upon completion. Furthermore, because large projects involve many people, collaboration naturally generates records—email discussions, proposal reviews, and code comments—all of which serve as natural externalizations of knowledge. The result of high institutional density is that even if an individual does not want to write, the system will compel them to do so.

The institutional density of daily operations is moderate. There are incident report templates for handling failures, change request forms for implementing changes, and logs for routine inspections. After years of operation, these have become an integral part of the work. You do not perceive this as “extra documentation,” but rather as “necessary steps to complete the work.”

The institutional density of small-scale projects is virtually zero. Upon completion, they generally require only a technical report, with a paper being the most that might be added. No one requires you to document the process, decision logs, justifications for parameter choices, or lessons learned from trial and error. Moreover, small-scale projects have few people involved; one person handles most of the work, so there are none of the records that naturally arise from collaboration.

Therefore, my core conclusion is this: small-scale projects exist in a vacuum where institutional frameworks are absent. Their knowledge production model relies on individual tacit knowledge just as much as large-scale projects do, but the institutional density is much lower—even lower than that of routine operations and maintenance. This disparity is the root cause of the knowledge management dilemma (as shown in Figure 1).



Fig. 1. Comparison of Institutional Density in Three Types of Research Scenarios

2.4 The Logic of Mismatch Between Exploratory Activities and Exploitative Institutions

The disparity in institutional density mentioned above is not coincidental. It can be explained more clearly using March's exploration-exploitation framework. March points out that organizational learning involves a fundamental contradiction: the conflict between exploring new things and making good use of existing ones. The goal of exploratory activities is to discover new knowledge; they are characterized by unclear objectives, uncertain paths, and unpredictable outcomes. The goal of exploitation activities is to optimize existing knowledge; they are characterized by clear objectives, well-established paths, and predictable outcomes.

An organization's knowledge management systems — whether documentation standards, process templates, or review criteria — are essentially designed for exploitation activities. Since the output format of exploitation activities is known, templates can be designed in advance. Why are there templates for fault reports? Because we know which elements need to be recorded when resolving a fault. Why do change requests have a specific format? Because we know exactly what information needs to be documented for a change operation. These templates are effective precisely because the activities themselves are repetitive and predictable.

The form of output from exploratory activities is unknown in advance. A simulation might uncover new patterns or prove that a particular line of thinking is unfeasible; the nature of this knowledge is only revealed after the activity is completed. You cannot design an "exploratory activity process record form" in advance because you do not know what types of decisions or discoveries this exploration will involve. Therefore, exploratory activities are inherently difficult to standardize. The two types of activities exhibit significant differences in terms of goal clarity, path certainty, output predictability, and institutional fit (as shown in Figure 2).

Consequently, the low institutional density in small-scale research projects does not stem from flaws in institutional design, but rather from a fundamental mismatch between exploratory activities and an exploitation-oriented institutional framework. When we attempt to manage exploratory activities using tools designed for exploitation-oriented activities, institutional gaps are bound to arise.

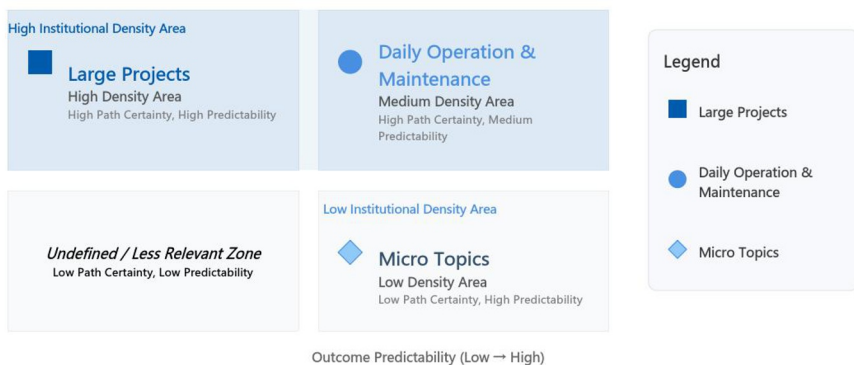


Fig. 2. Institutional Matching Matrix of Exploratory and Exploitative Activities

3 Case Presentation and Analysis of Bottlenecks

The project I monitored is titled “Research on DNS Resolution Modeling and Simulation Based on X.” This is a small-scale project initiated by the organization itself, with a budget of 30,000 yuan, a duration of 12 months, and a team of five members. The project’s objective is to develop a graph neural network model for the resolution service system of the .CN top-level domain. As the project manager, I monitored the entire process using participatory observation, focusing specifically on the points where knowledge flow became stalled between individuals and the organization.

Why was this project chosen as a case study? First, it is a typical example of a small-scale project, characterized by limited funding, a small team, and a short duration—all hallmarks of such initiatives. Second, its technical content involves a certain level of complexity, specifically graph neural network modeling, which involves numerous decision points throughout the process, making it easy to observe bottlenecks in knowledge flow. Finally, as the project manager, I was able to monitor the entire process and had the opportunity to conduct in-depth participatory observation. From inception to completion, the project went through four phases, each with specific points of knowledge loss, forming a funnel structure with progressively decreasing efficiency (as shown in Figure 3).

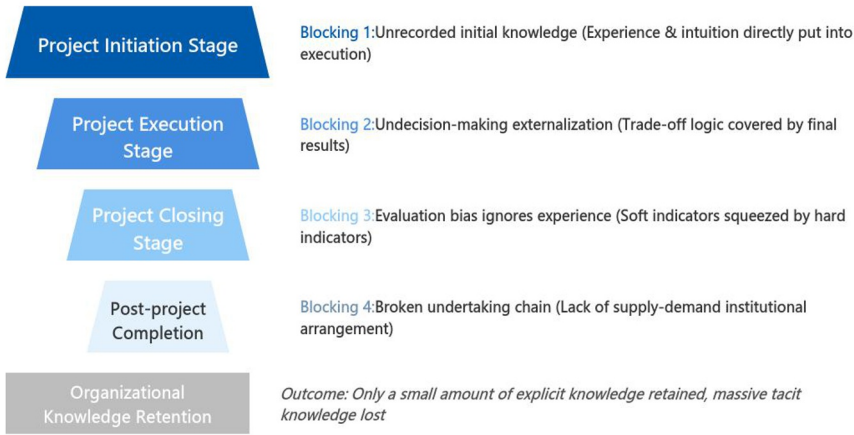


Fig. 3. Four-fold Blocking Funnel Model of Knowledge Flow in Micro Topics

3.1 Initial Stagnation and the Institutional Invisibility of Foundational Knowledge

At the outset of the project, the technical lead’s understanding of the DNS resolution system was based on his years of operations experience. When selecting the scope of

the model, he almost instinctively remarked, “It would make more sense to start with the node cluster in a specific region.” When asked why he chose that region, he replied, “The architecture there is unique, and we’ve encountered a few minor issues there before.” This insight was valuable, demonstrating how operational experience can guide research direction. However, the project team failed to document the rationale behind this choice.

This bottleneck reflects the failure to document the project’s foundational knowledge. In large-scale projects, the project initiation phase includes expert reviews and requirements analysis documents that clearly record why the project begins where it does. Small-scale projects lack these steps; personal experience leads directly to execution, and the rationale undergoes no formal documentation. If future team members wish to understand why the simulation scope was defined in a certain way, they can only see the conclusion, not the reasoning. If they fail to grasp the logic behind this initial choice, they may repeat attempts that have already been proven unsuitable or overlook the issues that truly require attention.

3.2 Execution-Phase Bottlenecks and the Systematic Loss of Decision-Making Knowledge

The process of modeling graph neural networks involves selecting from a vast array of parameters and methods. For example, regarding how to assign edge weights, the technical team had three options: using only latency, using latency plus packet loss rate, or using latency plus AS hop count. Ultimately, they chose latency plus packet loss rate. The rationale was that latency alone fails to reflect fluctuations in link quality, while packet loss rate supplements this information; furthermore, AS hop count holds little reference value in the context of China’s backbone network. This thought process took nearly two hours.

However, in the technical report, this decision was reduced to a single sentence: “Edge weights are determined by a weighted combination of latency and packet loss rate.” The information most useful to future researchers — such as why other approaches were not used and under what circumstances a reevaluation might be necessary — was entirely omitted. Exploratory activities involve many such minor decisions; in large-scale projects, decisions of this level are documented in review records or design specifications, but in small-scale projects, the documentation density for these decisions is virtually zero. The gap between high-frequency cognitive decision-making and zero institutional density leads to a massive loss of knowledge regarding decision-making processes.

It should be noted here that technical leads are not unwilling to document; rather, no one requires them to do so, and there are no suitable templates for them to use. If asked to write a decision rationale from scratch, they might feel unsure of what to include or how much detail to provide. However, if guided by a simple question — such as “Why was parameter A chosen over B?” — they can actually explain it very clearly. The issue lies not in individual willingness, but in the lack of a triggering mechanism.

3.3 Stagnation in the Wind-Down Phase and Attention Bias in the Evaluation System

As a project nears completion, technical leads focus their energy primarily on two tasks: refining the charts and tables in the technical report and writing academic papers. Managers, meanwhile, focus on whether the final budget settlement is compliant and whether the project closure materials are complete. Neither side treats “systematizing lessons learned from the modeling process” as a task requiring dedicated time.

This is not an attitude issue, but rather a result of the evaluation system’s differing requirements for different types of outputs. The hard metrics for project acceptance are deliverables, which have clear formatting requirements and acceptance criteria directly tied to whether the project passes or fails. Knowledge consolidation is a soft metric, with zero institutional support; it is neither subject to acceptance nor evaluation. Given limited time, soft metrics are inevitably squeezed out by hard metrics. This allocation of attention stems from institutional design, not individual laziness. Research has also pointed out that in the evaluation of knowledge management capabilities within research institutions, institutional support for knowledge retention and transformation is generally insufficient [3].

In fact, managers are well aware that there is much valuable experience worth preserving during the process, but within the existing project completion procedures, there is no specific step dedicated to this task. The project completion forms require entries for budget settlements, lists of achievements, and self-evaluations—but there is no section labeled “summary of process experiences.” Naturally, no one will go out of their way to do something that isn’t on the form.

3.4 Post-Completion Stagnation and the Break in the Knowledge Continuity Chain

After a project is completed, key technical staff return to their routine operations and maintenance work. New insights gained during the project may occasionally surface in their conversations—such as analyzing DNS dependencies from a graph theory perspective—but such spillover is sporadic and unsystematic. More importantly, it is entirely uncertain whether the organization will undertake similar projects in the future or if new projects will emerge to build upon the experience gained from this one.

Large-scale projects typically have explicit knowledge transfer requirements, such as handing over design documents and operations manuals to the operations team; these requirements create a demand for knowledge. Research indicates that the key to knowledge transfer lies in establishing institutionalized interfaces between the supply and demand sides^[4]. Small-scale projects, however, lack both requirements for knowledge recipients and institutional arrangements for subsequent projects to retrieve or reference them. The knowledge supply side has no incentive to externalize the knowledge, and the demand side lacks mechanisms to access it; with institutional

frameworks absent on both sides, the knowledge rapidly becomes obsolete once the project concludes.

4 Structural Causes of the Lack of Institutional Density

These four bottlenecks point to a deeper issue. The lack of institutional density in small-scale research projects is not due to administrative oversight, but rather stems from the very nature of such projects as exploratory activities.

4.1 Time Budget Constraints and the Incompatibility of Externalized Costs

With project funding amounting to only tens of thousands of yuan, the amount of effective working time that can be purchased based on labor costs is very limited. Project leaders must complete core technical work within this limited timeframe. Knowledge externalization—clarifying and documenting “why a particular choice was made”—requires additional cognitive resources and time. Transforming vague intuition into clear text is, in itself, a mentally demanding task.

However, this cost is not factored into the project’s time budget. The proposal outlines the technical objectives to be achieved and the papers and reports to be produced, but there is no budget allocated for “documenting process knowledge.” The economic model of small-scale projects does not include the cost of knowledge externalization from the outset. When time is scarce, completing the core work is a hard requirement, while documenting process knowledge is a soft expectation—the outcome is predictable.

Some might say, “Isn’t it just a matter of writing a few hundred extra words? How much time could that possibly take?” But the reality is different. Articulating tacit knowledge clearly is not a matter of typing; it is a matter of thinking. You need to recall the context in which decisions were made, sort through the factors considered at the time, and then organize them into language that others can understand. This process may take even longer than making the decisions themselves. For a small-scale project already operating under tight time constraints, this cost is indeed significant.

4.2 The Attention Allocation Mechanism of the Evaluation System

The final project review focuses on whether “the commitments made in the proposal have been fulfilled.” Whether simulation models have been built, whether accuracy targets have been met, and whether papers have been submitted—these are the concerns of the review experts. Since the documentation of knowledge processes falls outside the scope of these commitments, it naturally falls outside the scope of the review. When the externalization of knowledge does not serve as a basis for evaluating individuals or teams, any rational person would prioritize it last.

This is not a flaw in the evaluation system, but rather a consequence of its defined functional boundaries. The core function of the evaluation system is to verify whether deliverables meet standards, not to capture process knowledge. Incorporating process

knowledge into evaluation requires entirely different approaches and criteria — it cannot be resolved simply by adding a checkbox. Within the current framework, the externalization of process knowledge lacks both institutional incentives and evaluative drivers, naturally leaving it in a vacuum.

Another practical issue is that process knowledge is difficult to evaluate. How do you judge whether a process record is well-written? A detailed record may be verbose, while a concise one may omit key information. Moreover, the forms of process knowledge vary greatly across different projects, making it impossible to measure them with a uniform standard. Evaluation systems inherently favor things that are comparable and quantifiable, yet process knowledge is precisely difficult to compare and quantify.

4.3 The Marginal Status of Exploratory Activities in Institutional Systems

In the organization's project classification, small and micro-scale projects rank lower than government-funded projects and major special projects. Government-funded projects are subject to acceptance requirements from higher-level authorities, and documentation standards are strictly enforced. Major special projects involve substantial funding and multi-party collaboration, with clear institutional frameworks for records management. Small and micro-scale projects, however, do not qualify as formal research projects subject to documentation standards, nor do they fall under routine operations and maintenance work requiring operational records.

This ambiguous positioning leaves them as an institutional “enclave” outside the scope of established systems. At a deeper level, this reflects the organization's contradictory attitude toward exploratory activities. On the one hand, the organization encourages staff to apply for independent projects to pursue technological exploration; on the other hand, it is unwilling to invest the same level of institutional resources in such exploration as it does in applied activities. Exploration is granted symbolic recognition but remains marginalized in terms of resource allocation and institutional arrangements. This contradiction between encouragement in attitude and neglect in institutional support is the organizational root cause of the knowledge management dilemma facing small and micro-projects.

Put simply, in the eyes of the organization, small and micro-projects are seen as “icing on the cake,” not “a lifeline in times of need.” It's certainly good if they succeed, but it's no big deal if they fail. This positioning determines that they will not receive significant institutional resources. Establishing documentation standards for large projects is essential, as problems with them have far-reaching consequences; for small and micro-projects, however, such standards become an “extra burden” because their importance does not warrant it.

5 Reconstructing the Logic of Knowledge Management in Low-Institutional-Density Scenarios

If the lack of institutional density is structural and cannot be eliminated, then knowledge management for small-scale projects cannot follow the path of “increasing institutional density.” Simply scaling down the documentation system used for large projects and applying it to small projects will not only undermine the latter’s advantage of being lightweight but will also prove fundamentally unworkable. No one would assign a full set of documentation standards to a project worth only a few tens of thousands of yuan. The question then becomes: Given that low institutional density is an unchangeable reality, is there a different approach to knowledge management?

5.1 The Shift in Strategic Logic and Its Theoretical Basis

The strategy in high-institutional-density scenarios relies on institutional compulsion—using rules and processes to embed externalization into work, forcing individuals to document. This approach cannot be applied in low-institutional-density scenarios because they lack the resources and legitimacy to enforce such compulsion. I believe low-institutional-density scenarios should adopt a cognitive-trigger strategy. This involves placing a very light intervention at natural nodes in the flow of knowledge, using minimal effort to awaken an individual’s willingness to express themselves.

The distinction between the two lies in this: institutional enforcement says, “You must document,” relying on organizational authority and rewards/punishments; cognitive triggering says, “You can start here,” relying on reducing the difficulty of expression and endowing expression with meaning. Institutional enforcement is suitable for producing predictable, utilitarian activities, while cognitive triggering is suitable for producing exploratory activities with uncertain outcomes. The essence of this shift is acknowledging constraints and finding solutions within them.

The approach of cognitive triggering is not to ask people to do more, but to slightly alter the format of existing activities. For example, since a meeting with management is already required at the project’s conclusion, we can make that conversation more structured by asking a few questions designed to elicit process knowledge. This does not add time, but it captures knowledge that would otherwise be lost.

5.2 Design Elements of the Cognitive Trigger Strategy

Based on case reflections and management practices, I have identified three design elements for the cognitive trigger strategy.

First, timing integration. Cognitive triggers must be embedded within existing management actions; they cannot be implemented as a separate process. The project completion review is a natural touchpoint. Project implementers have just completed the entire cognitive process, their memories are still fresh, and managers and implementers are certain to engage in dialogue at this stage. Embedding knowledge

capture into this dialogue incurs no additional time costs. In addition to project completion, existing milestones such as mid-term reviews and kick-off meetings can also be utilized.

Second, question-driven approach. The core tool for cognitive triggering is asking questions, not making demands. Question design follows two principles. First, questions must be specific; ask, “Is there a decision that took you a long time to make?” rather than “Summarize your lessons learned.” Specific questions lower the cognitive cost of expressing one’s thoughts. Second, focus on knowledge transfer: ask, “If you were to advise next year’s new hires, what would you say?” rather than “What have you learned?” This approach makes people feel that their experience will be valuable to those who come after them, giving their insights a sense of external significance. People are naturally willing to help others; if they know their words will be put to use by future colleagues, they will be more willing to speak up and offer more substantive advice. Research indicates that the key to making tacit knowledge explicit lies in creating a context where expression is “needed” [5].

Third, zero additional burden. The output format triggered by this cognitive process should be extremely simple. The “three-question closing dialogue” I tried in the case study—where a manager compiles a one-page summary after a 30-minute conversation—embodies this approach. We don’t aim for completeness; we just aim for something better than nothing. We do not enforce a specific format; we only require that the key point to be conveyed be clearly articulated. It is not used as a basis for evaluation, but rather as a lightweight supplement to the organization’s knowledge base. A one-page document requires the manager to spend half an hour compiling it and the executor to spend half an hour in dialogue—a total cost of one hour—in exchange for a piece of experience that can be passed on to future generations. This return on investment is well worth it.

These three elements form a progressive structure ranging from foundational basics to overarching principles (as shown in Figure 4).



Fig. 4. Pyramid Model of Three Elements of Cognitive Trigger Strategy

5.3 The Sensitivity of the Explicitization Stage to Institutional Density

The findings of this paper add a new perspective to the SECI model: the explicitization stage is particularly sensitive to institutional density. Among the four stages of the SECI model, explicitization is the stage most dependent on institutional conditions and also the most vulnerable.

Socialization can occur naturally through apprenticeship and shared practice, without the need to explicitly articulate knowledge. Internalization is achieved through individual learning, where the learning materials are already explicit knowledge. Combination can be supported by information systems, which organize and categorize dispersed explicit knowledge. Only externalization—the process of transforming ambiguous tacit knowledge into clear, organized, and communicable form—is highly unlikely to occur without institutional support. Externalization requires individuals to actively examine their own knowledge structures through metacognition and then encode them into language; this process involves a heavy cognitive burden, which people naturally tend to avoid. Institutional density plays a moderating role in the externalization stage of the SECI model: high institutional density promotes it, while low institutional density inhibits it (as shown in Figure 5).

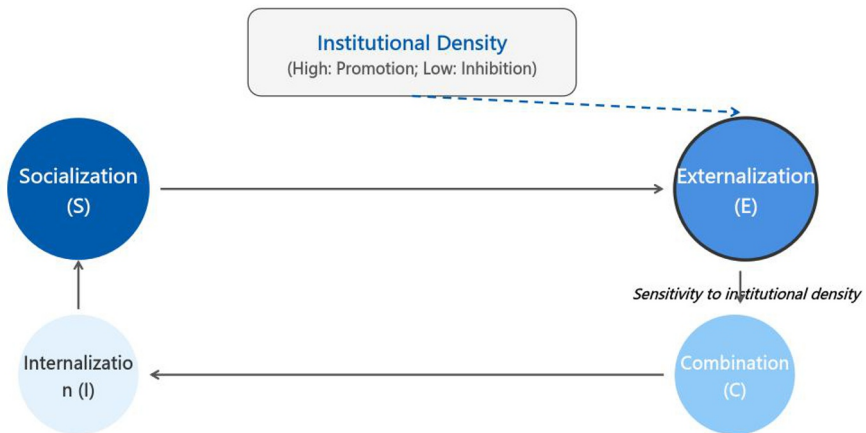


Fig. 5. Pyramid Model of Three Elements of Cognitive Trigger Strategy

This perspective explains why the full SECI cycle does not function in environments with low institutional density. Within the small cycle—from socialization to internalization—knowledge can facilitate cognitive advancement at the individual level, and technical experts do indeed gain a deeper understanding than before. However, the larger cycle—from externalization to combination—breaks down due to insufficient institutional density, leaving the organization with nothing to show for it. This not only explains the phenomenon but also identifies the key focus for intervention: when it is not possible to increase institutional density across the

board, efforts should concentrate on establishing cognitive triggers within the externalization phase.

5.4 Implications for Management Practice and Identification of Knowledge Blind Spots

The value of the concept of institutional density extends beyond explaining small-scale issues. It provides an analytical tool to help managers identify low-institutional-density knowledge blind spots within the organization—areas where knowledge production is active but institutional frameworks do not reach.

Exploratory projects, ad-hoc task forces, cross-departmental collaboration, new employees' trial-and-error, and preliminary technical research all share similar characteristics: knowledge relies on individual judgment, yet there are no formal channels for its externalization. What they have in common is that they operate outside routine processes and are not incorporated into formal institutional management systems, yet the knowledge they generate holds potential value for the organization's long-term capacity building. The criterion for identifying these blind spots is not "whether someone is in charge," but "whether there is an institutionalized interface for knowledge externalization." Research has also found that in project-based organizations, the loss of lessons learned is often most severe in small-scale activities that fall outside the scope of formal systems^[5].

The Cognitive Trigger Strategy provides a set of transferable practices for these scenarios: rather than attempting to establish formal systems, identify natural touchpoints, design guiding questions, and accept incomplete outputs. For exploratory projects, a question about "the most unexpected discovery" can be added to mid-project reports. For ad-hoc working groups, a 15-minute discussion on "What would you change if you did it again?" can be held before disbandment. For newcomers' trial-and-error, mentors can conduct regular, lightweight interviews on "recent pitfalls encountered." The common thread among these practices is acknowledging the constraints of low institutional density and finding the minimum viable solution within those constraints.

6 Conclusion and Outlook

The knowledge management dilemma in small-scale research projects stems not from individual laziness, but from a structural mismatch between exploratory activities and an outcome-oriented institutional environment. This paper uses the concept of institutional density to explain how this mismatch arises. Large projects have external support with high institutional density, while daily operations are embedded in processes with moderate institutional density; small-scale projects, however, exist in a vacuum of institutional density. This disparity explains the counterintuitive phenomenon that "the smaller the scale, the higher the attrition."

The solution is not to compress the institutional framework of large projects and impose it on small projects, as that would undermine their lightweight advantage.

What is truly needed is a fundamental shift in strategic logic—from institutional coercion to cognitive triggering. The cognitive trigger strategy, based on three elements—timing integration, problem-driven guidance, and zero additional burden—provides an actionable and transferable approach to knowledge capture in low-institutional-density scenarios. This strategy was preliminarily tested in the case study presented here, though its effectiveness requires further validation across a wider range of small-scale projects.

From a broader perspective, the knowledge management challenges faced by small-scale projects reflect the common predicament of all exploratory activities. In an organization that prioritizes certainty and efficiency, the question of how to carve out institutional space for exploratory knowledge production is a challenge that extends far beyond the scope of individual project management. The concept of institutional density and the cognitive trigger strategy proposed in this paper represent a preliminary attempt to address this issue. Future research could explore differences in attention conversion efficiency across various project types, as well as how individual characteristics influence the effectiveness of cognitive triggers, thereby accumulating more empirical evidence for knowledge management in low-institutional-density settings.

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The authors have no competing interests to declare that are relevant to the content of this article.

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