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THE ROLES OF MATERIAL ARTIFACTS IN MANAGING THE LEARNING–PERFORMANCE PARADOX: THE KAIZEN CASE

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This paper aims to uncover the roles of material artifacts in managing the learning–performance paradox. It analyzes qualitative data on two transformation projects to implement kaizen (continuous improvement) collected from two manufacturing plants in a Chinese company. In both projects, material artifacts triggered social interaction, through which frontline employees were stimulated to focus on both performance and learning. However, in one project, the interplay of material artifacts that play multiple roles led to competing understandings of organizational objectives between managerial staff and frontline employees, which resulted in regression to the previous state where frontline employees focused exclusively on performance. In the other project, by contrast, the interplay of artifacts led to interrelating understandings of organizational objectives between these actor groups, which resulted in frontline employees' constant acceptance of the learning–performance paradox. This paper contributes to extant literature by showing how the interplay of material artifacts that play multiple roles, such as triggering, supporting, disconnecting, and connecting, contributes to rendering paradox salient, as well as to creating organizational contexts for actors' responses to it.

This paper aims to develop a theory on the roles of material artifacts in the management of paradox (Smith, Lewis, Jarzabkowski, & Langley, 2017). It particularly focuses on the learning–performance paradox (Dobrow, Smith, & Posner, 2011; Lewis & Smith, 2014) that frontline employees face when they engage in incremental innovation (Abernathy, 1978; Benner & Tushman, 2003). To achieve this aim, I conducted process studies on transformation projects to implement kaizen (continuous improvement) in a Chinese manufacturing plant. Kaizen is known as an essential part of the Toyota Production System (TPS), or "lean system" (Ohno, 1988a; Shimokawa & Fujimoto, 2009; Womack & Jones, 1996). In kaizen implementation, frontline employees are expected to adhere to standardized procedures for ensuring efficient performance, while at the same time they are expected to experiment and seek new ideas for improving the existing procedures (Adler, 1993; Imai, 1986; Ohno, 1988b). This can be problematic, as experimenting and seeking new ideas give actors learning opportunities, but can lead to challenges in terms of maintaining efficient performance (Lewis & Smith, 2014). Frontline employees who engage in kaizen, therefore, have to address the learning–performance paradox.

Paradox scholars have developed theories on the constructive use of paradox that can lead to the improvement of performance and innovation (Lewis, 2000; Poole & Van de Ven, 1989; Smith, 2014). These positive results can be achieved in situations where paradoxes become salient for actors, rather than situations where actors avoid or ignore paradoxes (Clegg, Cuhna, & Cuhna, 2002; Lewis & Smith, 2014). Past studies have explored environmental factors that render latent paradoxes salient for actors, such as plurality, change, and scarcity (Miron-Spektor, Ingram, Keller, Smith, & Lewis, 2018; Smith & Lewis, 2011). Recent paradox scholars, informed by a practice lens (Lê & Bednarek, 2017), have paid particular attention to social interactions or discursive interactions, through which actors construct paradox and their responses to it (e.g., Bednarek, Paroutis, & Sillince, 2017; Jarzabkowski & Lê, 2017; Smets, Jarzabkowski, Burke, & Spee, 2015). The practice lens allows researchers to analyze paradox with a strong focus on everyday practice that shapes paradox and actors' responses to it. I also share this research focus in the present paper.

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Among practice scholars there has been increasing recognition that materials, such as artifacts and tools, instantiate "epistemic objects" (Knorr-Cetina, 1997; Rheinberger, 1997), which constitute structural conditions for the unfolding processes of innovative projects (Knorr-Cetina, 2001; Werle & Seidl, 2015). Lean scholars have also recognized the importance of material artifacts, such as "kanban" (production order) cards and "andon" (line stop indication) boards, in managing kaizen (e.g., Adler, 1993; Imai, 1997; Spear & Bowen, 1999). They have shown that Toyota, and several other large Japanese organizations, make use of these artifacts in ways that stimulate frontline employees to follow standardized procedures (performance), as well as to seek new ideas for improving the procedures (learning). However, little is known about how organizations that try to implement incremental innovation or kaizen become able to use such artifacts in ways that continuously encourage frontline employees to pay attention to both performance and learning.

Despite the increasing importance of material artifacts in managing paradox, paradox scholars have not yet fully explored the role of materiality by moving their focus beyond discourse (Lê & Bednarek, 2017). Some scholars have suggested that material artifacts can constitute structural conditions for rendering paradoxical tensions salient (Knight & Paroutis, 2017), or mediate the control–collaboration paradox (Michaud, 2014). However, existing studies have not yet developed sufficient theoretical insights into how artifacts used in everyday interactions, such as pictures and tables that show certain situations or performance, contribute to shaping paradox and actors' responses to it. This paper aims to develop such theoretical insights for organizations that try to promote incremental innovation in which frontline employees embrace the learning–performance paradox in a sustainable manner. This paper thus asks: *How do material artifacts contribute to transforming organizations in ways that effectively manage the learning–performance paradox?*

To address this question, I analyzed in-depth qualitative data on two transformation projects to implement kaizen collected from different plants in a Chinese manufacturing company. My analysis resulted in the identification of four distinct roles of material artifacts, triggering, supporting, disconnecting, and connecting. In both projects, the triggering role stimulated frontline employees to pay attention to both performance and learning—i.e., rendering the learning–performance paradox salient. However, in one project the interplay of triggering, supporting, and disconnecting led to competing understandings of organizational objectives between managerial staff and frontline employees. Guided by the theory of epistemic objects, I define this situation as "competing epistemic objects." In the other project, the interplay of triggering, supporting, and connecting led to interrelating understandings of organizational objectives between these actor groups ("interrelating epistemic objects"). The competing or interrelating epistemic objects created organizational contexts for actors' responses to the paradox. The former resulted in regression to the previous state where frontline employees focused exclusively on performance, while the latter resulted in their ongoing acceptance of the learning–performance paradox.

THEORETICAL BACKGROUND

A Paradox Perspective and the Learning–Performance Paradox

Paradox has been defined as "contradictory yet interrelated elements that exist simultaneously and persist over time" (Smith & Lewis, 2011: 382). A paradox perspective stands in stark contrast to contingency theory, which recommends the choice of an appropriate management style (e.g., a flexibility-oriented or efficiency-oriented) under certain conditions (e.g., a stable or changing environment). Although the contingency perspective sees paradoxes as organizational problems in need of solutions (Lewis & Smith, 2014), the paradox perspective encourages maintaining paradoxes in order to trigger innovation and creativity (Cameron & Quinn, 1988; Luscher & Lewis, 2008; Schad, Lewis, Raisch, & Smith, 2016), and to look for holistic synergies between contradictory elements (Andriopoulos & Lewis, 2009; Hargrave & Van de Ven, 2017; Smith, 2014).

One typical example of paradox is the exploitation–exploration paradox—that is, the paradox between the use of existing knowledge for increasing efficiency and the pursuit of new knowledge for adapting to a changing environment (Andriopoulos & Lewis, 2009; March, 1991; O'Reilly & Tushman, 2013). Pursuing these contradictory goals simultaneously is difficult for organizations, but could lead to sustained performance (Raisch, Birkinshaw, Probst, & Tushman, 2009; Smith & Tushman, 2005). Past studies of Toyota have shown how this company continuously pursues exploitation and exploration simultaneously, which allows it to excel in terms of both short-term and long-term performance (Aoki & Staeblein, 2018; Aoki & Wilhelm, 2017), and make both incremental and

radical innovations (Brunner, Staats, Tushman, & Upton, 2010; Osono, Shimizu, & Takeuchi, 2008).

The learning–performance paradox at the center of this paper seems to have attracted less attention than the exploitation–exploration paradox. The paradoxes have similarities in that efficient performance facilitates exploitation, while learning becomes the basis for exploration. However, these paradoxes can be distinguished, since the exploitation–exploration paradox refers to tensions linked to the allocation of resources at the macro level of organizations (March, 1991), while the learning–performance paradox refers to tensions linked to actors' orientation at the micro level (Lewis & Smith, 2014). Furthermore, the latter paradox is more closely linked to incremental innovation or kaizen, in which frontline employees' orientation plays a key role (Adler, Goldoftas, & Levine, 1999; Imai, 1997; Spear & Bowen, 1999). In general, frontline employees at a manufacturing plant are expected to adhere to standardized procedures to ensure the efficiency and quality of their operations (Adler, 1993; Liker, 2004; Ohno, 1988a). A traditional Western management approach, or Taylorism (Taylor, 1911), stipulates that frontline employees focus exclusively on following standardized procedures, while knowledge work is undertaken by management; this has been defined by Braverman (1974: 79) as "separation of conception from execution."

In contrast with the traditional Western approach, which represents an either–or perspective, the Japanese kaizen approach, or Toyotism (Ohno, 1988a), embraces a both–and (paradoxical) perspective (Eisenhardt & Westcott, 1988; Osono et al., 2008). This approach puts emphasis not only on frontline employees' adherence to standardized procedures but also on allowing them learning opportunities where they can show their creativity and use their wits (Adler, 1993; Ohno, 1988b). In fact, Toyota asks frontline employees to try and detect the root cause of problems (Liker, 2004; Ohno, 1988a), which enables the company to promote incremental innovation (Adler et al., 1999; Spear & Bowen, 1999). In kaizen implementation, therefore, frontline employees need to have contradictory orientations: one is to be disciplined to ensure efficient performance—performance orientation; the other is to be creative to seek new ideas and better processes—learning orientation (Lewis & Smith, 2014).

The kaizen approach, however, assumes that learning and performance are not only *contradictory* but also *interrelated*. In fact, this approach aims for synergies in terms of human and skill development, which are created when employees engage in activities for ensuring efficient performance, as well as for seeking new ideas and experimenting for improvement (Adler et al., 1999; Liker, 2004; Spear & Bowen, 1999). Furthermore, in kaizen implementation frontline employees are always expected to consider both performance and learning, since, according to Taiichi Ohno (1988a), who is considered the founder of TPS, kaizen is a never-ending process (i.e., *persistence*). The learning–performance paradox in kaizen implementation, therefore, fits well into a paradox perspective that puts emphasis on *contradiction*, *interrelatedness,* and *persistence* as the core elements of paradox (Schad et al., 2016).

A paradox perspective regards paradoxes as "inherent and ubiquitous in organizational life" (Lewis & Smith, 2014: 132), or as "part of the everyday practice of management" (Clegg et al., 2002: 499). Paradoxes, however, are not always salient for actors, and may remain latent or be ignored (Knight & Paroutis, 2017; Smith, 2014). If latent paradoxes become salient, the paradoxes do not always elicit actors' positive, innovative responses, but can rather fuel their anxiety and defensiveness, which may create vicious cycles in organizations (Jarzabkowski, Lê, & Van de Ven, 2013a; Lewis, 2000; Vince & Broussine, 1996). Smith and Lewis (2011) incorporated these issues into a dynamic equilibrium model stating that organizations need to manage not only how paradoxes emerge among actors, but also how actors respond to the paradoxes.

As stated above, practice-based paradox studies (Lê & Bednarek, 2017) have provided insightful implications for managing the two processes with a strong focus on everyday interactions—discursive interactions in particular. For example, Jarzabkowski and Lê (2017), using the case of a telecommunications company, showed that paradoxes are constructed through discursive interactions using humor (e.g., talking about paradoxical tensions by making jokes). They further showed that such interactions shape the way actors formulate and legitimate their responses to the paradoxes. Knight and Paroutis (2017) revealed that top leaders' interactions with lower-level managers contribute to shaping the conditions that render latent paradoxical tensions salient in a sustainable manner. The present paper, informed by the dynamic equilibrium model and practice-based studies, analyzes how social interaction using artifacts contributes to shaping paradox, as well as actors' responses to paradox.

However, this paper aims to take this stream of research a step further by paying close attention to the roles of material artifacts. In fact, Knight and Paroutis (2017: 425) indicated the importance of

expanding our horizon to consider material artifacts, stating that artifacts contribute to shaping "the interpretive contexts for lower-level managers through the provision of cues." However, they did not analyze in detail how social interaction using artifacts allows actors to sustain paradox. Michaud (2014) analyzed numbers, such as numerical targets and results, that act as "mediation objects" (Hussenot & Missonier, 2010), and showed how number-supported practices enable actors to embrace the control–collaboration paradox. Although Michaud's (2014) study highlighted the role of material objects that mediate the paradox, it limited its discussion to specific types of objects, or "numbers." The present paper expands the scope of discussion to include various material artifacts, such as pictures, tables, and standardized operating procedures (SOPs) used by frontline employees in everyday work. By doing so, I aim to provide a more comprehensive understanding of the roles of material artifacts in the management of paradox.

Material Artifacts and Epistemic Objects

Although existing lean studies have not extensively analyzed the roles of material artifacts in association with the learning–performance paradox, some studies have suggested how material artifacts are closely related to this paradox (e.g., Brunner et al., 2010; Spear & Bowen, 1999). In fact, Toyota makes use of visual representations for directing frontline employees' attention to both standardized procedures and improvement activities, which is known as visual control (Adler, 1993; Fujimoto, 1999). A typical example is the use of SOPs. At Toyota, SOPs are posted in plain view on each shop floor, which allows supervisors to easily see whether operators are adhering to them (Liker, 2004; Shimokawa & Fujimoto, 2009). Here, SOPs are used to ensure efficient performance through encouraging operators' disciplined behavior. At the same time, frontline employees are allowed to revise SOPs by themselves, and use them as a means of finding better procedures (Adler, 1993; Liker, 2004). SOPs are therefore used for visually representing the objects of epistemic activities for improvement as well.

On the one hand, a considerable number of studies have shown how Toyota successfully implements kaizen (e.g., Fujimoto, 1999; Liker, 2004; Womack & Jones, 1996), suggesting that it also successfully manages the learning–performance paradox. On the other hand, there is little research on how organizations that are accustomed to a Western either–or perspective (Eisenhardt & Westcott, 1988; Keller, Loewenstein, & Yan, 2017), or the idea of Taylorism, successfully transform themselves into organizations that embrace the learning–performance paradox. Instead, studies on Western manufacturing plants have shown that the use of visual management artifacts, such as SOPs, kanban cards, and andon boards, leads to the intensification of disciplinary control, while decreasing opportunities for frontline employees to exercise their creativity (e.g., Delbridge, 1995; Sewell & Wilkinson, 1992).

An exception is New United Motors Manufacturing, Inc. (NUMMI), a joint venture between General Motors and Toyota (closed in 2010). According to Adler (1993), NUMMI, which was accustomed to the idea of Taylorism, had transformed itself into a plant that embraced Toyotism. Just like other Western plants, NUMMI used the aforementioned visual management artifacts. However, in this plant such artifacts induced frontline employees not only to strictly follow SOPs, but also to provide ideas for improving SOPs (Adler, 1993; Adler et al., 1999). This suggests that material artifacts might play a critical role in making frontline employees aware of the significance of paying attention to performance and learning simultaneously. Yet, Adler and his colleagues did not focus directly on the roles of material artifacts, nor did they provide detailed analysis of how material artifacts contribute to transforming the organization in ways that embrace the learning–performance paradox.

This paper analyzes the roles of material artifacts in making such a transformation, leveraging the theory of "epistemic objects" (Knorr-Cetina, 1997, 2001; Rheinberger, 1997). Epistemic objects are the material representation of objects of knowledge; they are characterized "in terms of a lack in completeness of being" (Knorr-Cetina, 2001: 181), and therefore "act as a source of interest and motivation" (Werle & Seidl, 2015: S70). Epistemic objects are theoretically distinguished from technical objects as fixed, ready-to-hand, and unproblematic instruments (Miettinen & Virkkunen, 2005; Rheinberger, 1997). Material artifacts, such as SOPs and performance tables, can be termed as technical objects when they are routinely used without problem. These artifacts, however, can instantiate epistemic objects when they display the objects of investigation (e.g., problematic situations).

Epistemic objects, therefore, are open and question generating, and are thus processes and projections rather than definitive things (Knorr-Cetina, 2001). The nesting structure of epistemic objects allows them to become ongoing, unfolding processes (Jarzabkowski, Spee, & Smets, 2013b; Werle & Seidl, 2015). According to Knorr-Cetina (2001: 182), epistemic objects "have multiple instantiations, which range from figurative,

mathematical, and other representations to material realizations." For example, material artifacts used in kaizen, such as SOPs, display boards, and production tools, can represent problematic situations to be solved. Such artifacts partly represent the incompleteness of the overall epistemic object (e.g., trying to create a seamless production flow as an objective of kaizen implementation), which Knorr-Cetina (2001) referred to as "partial objects."

Werle and Seidl (2015), based on their study on the development of strategic topics, showed how the interplay of material artifacts as partial objects dynamically evolves the overall strategic topic. They distinguished between primary partial objects that represent the overall topic, and secondary partial objects that represent only certain aspects of the topic. The interplay between the primary and secondary partial objects continuously motivates actors to explore a new strategic topic. Ewenstein and Whyte (2009), based on their study of an architectural design project, further showed that the interplay of material artifacts not only contributes to knowledge-development processes, but also enables collaboration between actors with different areas of expertise. These studies have suggested that the interplay of material artifacts creates conditions for the unfolding processes of project activities. The current paper attempts to refine this insight by focusing particularly on the roles of material artifacts that contribute to transforming organizations in ways that enable them to effectively manage the learning–performance paradox.

METHODS

I conducted qualitative process studies (Pettigrew, 1990; Van de Ven & Huber, 1990), which "provide explanations in terms of the sequence of events leading to an outcome" (Langley, 1999: 692), using data collected from a Chinese electronics parts maker (C-Maker). My analysis was aimed at uncovering the process through which organizations that were accustomed to the idea of Taylorism transformed themselves into those that embraced the learning–performance paradox in a sustainable manner. I analyzed transformation projects to implement kaizen that were led by a Japanese TPS expert at two main production plants of this maker.

Research Setting

C-Maker, with around 2,500 employees, was a family-owned company that had fewer than 10 years' experience in manufacturing at the time of December 2014, when the Japanese TPS expert was hired by this maker as a full-time managing consultant (hereafter TPS-C). Almost all parts produced by this maker were supplied to an electronic products company. This customer had a supplier rating system, which it evaluated quarterly, and gave the larger share of business to suppliers that achieved higher scores, whereas suppliers with lower scores would be given significantly less business. The customer made a particularly strong request to suppliers to conduct 5S—seiri (organization), seiton (orderliness), seiso (cleaning up), seiketsu (cleanliness), and shitsuke (discipline)—and actually frequently visited C-Maker to check its 5S situation.

Although C-Maker faced a constant need to improve its plant performance in terms of quality, cost, and 5S, it depended heavily on an old-fashioned mass-production system. Most of its frontline employees were paid according to the amount of work done, and focused almost exclusively on producing as many parts as possible per day. This meant that C-Maker initiated kaizen implementation with frontline employees who were unfamiliar with the kaizen concept. These employees recognized neither the need to pay careful attention to both performance and learning, nor the role of artifacts in kaizen implementation. Therefore, C-Maker provided an ideal setting in which the phenomenon of interest was "transparently observable" (Pettigrew, 1990; Stigliani & Ravasi, 2012).

TPS-C was hired with the primary objective of transforming such an old-fashioned production system to a TPS-based one, in which products were produced in a just-in-time (JIT) manner with continuously improved quality and productivity. TPS-C had more than 30 years' experience in Toyota, during which time he had won the best creative idea suggestion award and the best Quality Control (QC) circle presentation award, and had also qualified as an advanced TPS trainer. He spent much of his career at Toyota Kamigo engine plant as a skilled worker, and was actually involved in the introduction of the JIT system into this plant under Taiichi Ohno's supervision.

In December 2014, TPS-C embarked on the transformation project of its Machining and Assembly (M&A) plant with 1,200 employees (hereafter M&A project). In September 2015, TPS-C also embarked on the transformation project of its die-casting plant with around 1,000 employees (hereafter Die-Casting project). Both projects lasted until June 2016, when TPS-C's contract expired. I studied both cases during the period when TPS-C was hired by this company (December 2014–June 2016). Table 1 shows an overview of these cases.

TABLE 1
M&A and Die-Casting Projects in C-Maker

	M&A Project	Die-Casting Project
Plant and main operations	M&A plant with around 1,200 employees; large machine, small machine, assembly, and paint operations	Die-Casting plant with around 1,000 employees; die-casting and die maintenance operations
Main project members	TPS-C, project promoter 1, project promoter 2, frontline chief supervisors, frontline supervisors	TPS-C, project promoter 1, production manager, quality manager, frontline chief supervisors
Period	December 2014–June 2016	September 2015–June 2016
Objective	Establish 4S activities that embrace the kaizen concept in the organization	Implement TPS–JIT-based die changeover operations (continuously establish and improve standardized procedures)
Primary artifacts used	Red tags and pictures for highlighting problematic situations; problem follow-up sheets; boxes for containing parts and production tools; display cards and labels for clarifying rules and standards; painted lines on the shop floor for clarifying designated areas; tables and graphs used for showing production status; check sheets	Red tags, pictures and videos for highlighting problematic situations; problem follow-up sheets; boxes for containing parts and production tools; display cards and labels for clarifying rules and standards; painted lines on the shop floor for clarifying designated areas; tables and graphs used for showing production status; SOPs; sticky notes, lists, tables, and graphs used for problem analysis

Data Collection

Following recommendations on qualitative process studies (Langley, 1999; Pettigrew, 1990; Van de Ven & Poole, 1990), I relied on multiple data sources, including archival data, observations, and interviews. I made a particular effort to collect data such as pictures and videos, which not only fit well into the analysis of material artifacts (LeBaron, Jarzabkowski, Pratt, & Fetzer, 2018; Werle & Seidl, 2015), but also allow researchers to capture the emergence process of paradoxes more accurately and in more depth (Andriopoulos & Gotsi, 2017). I collected data for the entire processes of the two projects in C-Maker as shown in Table 2.

Archival data. In conducting this research, I received full support from TPS-C, including from his interpreter and project members, who allowed me to collect data on the two projects studied, and archival data on material artifacts used in the projects. These artifacts included pictures and videos that highlighted problematic situations, paper cards and labels that showed rules and standards, and tables and graphs used for analyzing problems (see Table 1). I obtained some examples of these artifacts that were created by TPS-C and actually used in the projects. I also obtained pictures and videos of artifacts that were created by project members and shown on plant floors or in meeting rooms. Some of them, such as those showing interactions between people and artifacts, were taken by me as a nonparticipant observer, while others, such as those actually used for identifying and analyzing problems by project members, were taken by the members themselves, including TPS-C. Furthermore, I obtained training materials that were used for instructing how to use these material artifacts, and activity reports that described the unfolding processes of the two projects (see Table 2).

Observations. As mentioned above, most of C-Maker's employees were unfamiliar with the kaizen concept, or the importance of paying attention to both performance and learning. Therefore, interactions between TPS-C and those employees were expected to be the most important opportunities for witnessing the emergence of the learning–performance paradox among the employees. For this reason, I focused on the observations of such interactions, and conducted a total of around 80 hours' on-site observations by shadowing TPS-C. The on-site observations included walking around shop floors; participating in project activities and meetings; and noting other interactions between TPS-C and employees, including both formal and informal ones (see Table 2 for formal interactions).

TPS-C basically conducted these activities with a Chinese interpreter, who provided word-for-word translations for TPS-C and the employees. I took notes about their interactions, paying particular attention to how they used material artifacts. For example, while walking around shop floors TPS-C stopped when he identified a problematic situation, such as randomly placed production tools, called the person in charge, and had a conversation with that person in which he pointed out the object of concern. I took notes of such conversations and took photos of

TABLE 2
Collected Data in Each Case

M&A Plant		Die-Casting Plant	
Archives			
Video-recorded operations (minutes)	68.2	Video-recorded operations (minutes)	667.1
Video-recorded plant conditions (minutes)	83.2	Pictures of activities, including analysis tools (number of pictures)	463
Video-recorded 4S activities (minutes)	5.8	Activity planning tables (pictures)	2
Video-recorded presentations of 4S activities (minuets)	39.5	Standard operating procedures (pictures)	7
Pictures of activities (number of pictures)	90	Standard operating procedures (samples)	3
Problem follow-up sheets (pictures)	4	Problem follow-up sheets (pictures)	2
Defective check sheet (picture)	1	Training materials (PowerPoint slides)	47
Kaizen evaluation sheets (samples)	29	Activity reports (PowerPoint slides)	164
Display (kanban) cards (samples)	4		
Training materials (PowerPoint slides)	58		
Activity reports (PowerPoint slides)	327		
Observations			
Walking around shop floor (number of instances)	7	Walking around shop floor (number of instances)	3
Shop floor 4S activities (number of instances)	3	TPS meetings (number of instances)	4
Problem follow-up meetings (number of instances)	3	Consultation meetings (number of instances)	2
Management training seminar (number of instances)	1		
Interviews			
TPS-C (common across the two plants)			7
President (common across the two plants)			2
Managing director	1	Production manager	1
Quality director	1	Quality manager	1
Production manager (roundtable meeting with TPS-C and a supervisor)	1	Project promoter 1	1
Project promoters (2 people)	3	Supervisors (2 people)	3
Supervisors (5 people)	6	Team leader	1
Team leader	1	Operator	1
Operators (2 people)	2		
Interview total	15	Interview total (including with employees common across the two plants)	17

the objects concerned. When TPS-C returned to his office, I often asked him and the interpreter to have a short meeting with me to confirm the accuracy of my field notes.

Interviews. I conducted a total of 32 semi-structured interviews with 20 informants from different organizational levels in the two plants (see Table 2). I asked TPS-C about the overview of kaizen implementation at C-Maker, including the background of kaizen implementation, such as customer needs, organizational climates, and employee skills and knowledge. I also conducted interviews with managerial staff, including the president of C-Maker, and the managing director (MD), the quality director, and a production manager in the M&A plant; and a production and quality manager in the die-casting plant. I asked them about the background issues, their interpretations of business environments, and their opinions about project activities. I further conducted interviews with frontline employees who constituted the workforce on plant floors, including supervisors, operators, and team leaders who were responsible for both supervising and conducting operational work, depending on the situation. I asked them questions such as how they interpreted the importance of kaizen implementation, how they engaged in project activities, and how they cooperated with others in these activities. I also posed these questions to project promoters 1 and 2, who worked closely with frontline employees on plant floors.

I encouraged these interviewees to feel free to talk about their impressions and opinions regarding the project activities. Interviews lasted between 30

minutes and two hours, almost all of which I recorded and fully transcribed. All interviews were conducted in Chinese, except those with TPS-C, which were conducted in Japanese. In my interviews with Chinese informants, the Chinese interpreter who was hired by TPS-C provided simultaneous interpretation. The trustworthiness of her interpretation, and of my interpretation of the two cases, was confirmed by repeated interactions with TPS-C. The interview data were also triangulated with data from other sources, such as observations and archival data, including videos, pictures, and reports.

Data Analysis

Step 1: Development of chronological case stories. My analytic approach was iterative and abductive, with the aim of developing a process model (Langley, 1999). I began by developing chronological case stories of the M&A and the Die-Casting projects, respectively. In this step, I attempted to understand the overall unfolding processes of the two transformation projects, focusing on broad issues, such as the backgrounds and objectives of the two projects and related events, and the implementation statuses of kaizen at the two plants. Through this initial analysis, I identified that both projects were considerably influenced by the "5S" project C-Maker had promoted before TPS-C was hired to meet the strong demand from the main customer. This focused frontline employees' attention narrowly on performance, rather than on learning. However, the Die-Casting project had weakened the influence of this old project, and instilled the kaizen concept into the organization more deeply, while the M&A project failed to do so. Based on this recognition, I attempted to identify several key themes related to the two transformation projects through data coding (Gioia, Corley, & Hamilton, 2013). I conducted first-order coding using interviewees' own terms as *in vivo* codes, which were subsequently linked to abstract, theoretically relevant themes, and then aggregated into further broader concepts. Tables 3a and 3b show examples of my coding process.

Step 2: Identification of the roles of material artifacts. In this step, first, I attempted to identify social interactions that directed actors' attention to both performance and learning, or that made the process of rendering the learning–performance paradox salient. I picked up social interactions using material artifacts conducted among TPS-C and the employees of C-Maker from my text data (i.e., field notes and transcripts). Among them, I attempted to identify situations in which employees were stimulated to pay attention to performance, as well as learning. For *performance*, I searched phrases related to the standardization of operational procedures that allowed the employees to efficiently conduct their operations. These phrases included "making and following a standard or rule," and "correcting and fixing a condition that deviated from a standard or rule," and to disciplined behaviors toward adherence to standardized procedures, such as "discipline (Shitsuke)" and "cleaning, and straightening up things." For *learning*, I searched words related to experimenting and seeking new ideas for improvement, such as "inventing, developing, and providing ideas," and "pursuing, detecting, and analyzing the cause of problems."

Then, I attempted to identify the roles of material artifacts used in such social interactions. I looked through all of my archival data, including samples, pictures, videos, training materials, and activity reports, and carefully compared visual data with text data. The main examples of the artifacts I identified are shown in Table 1. I found the pictures (or captured images) of these artifacts, and listed them on Excel spreadsheets with short comments for classification purposes, which resulted in the identification of three themes.

The first theme was related to artifacts that visually represented problematic situations, such as red tags, pictures, and videos. These artifacts triggered social interaction so that actors dealt with the problematic situations. Guided by extant literature on the role of visual representations that trigger epistemic activities (Dameron, Lê, & LeBaron, 2015; Werle & Seidl, 2015), I attached the label of "triggering" to this role. The second theme was related to artifacts that supported implementation of the transformation project (or kaizen), such as problem follow-up sheets, display cards and labels, and painted lines on the shop floor. I simply attached the label of "supporting" to the role of these artifacts. The third theme was related to artifacts that helped actors connect issues they faced, or activities they engaged in, to a broader objective related to the project. These artifacts included sticky notes, lists, tables, and graphs used for problem analysis. For example, a changeover time analysis tool connected activities for tidying up production tools to the reduction of changeover time. I attached the label of "connecting" to this role.

In the Die-Casting project, I identified that all three themes contributed to rendering the learning–performance paradox salient. However, in the M&A project I found little evidence that actors used artifacts that played the role of connecting. Instead, I identified artifacts that played the role of "*disconnecting*" actors, managerial staff in particular, from the project (the fourth theme). These artifacts included targets and rating scores given by the main customer, which directed actors' attention to the old 5S system.

TABLE 3A
Identified Themes and Representative Quotes or Descriptions in the M&A Case

Theme	First-Order Codes	Representative Quote Or Description
	Sociomaterial stimulation	
Triggering	Use of red tags for highlighting a problematic situation to be solved	A red tag is attached to work-in-progress parts placed randomly on the shop floor. After implementing a 4S red-tag practice, parts began to be placed in designated areas with display cards showing what these parts were. (Activity report on the M&A project)
	Pictures trigger interactions for kaizen activities	(When a picture showing an Numerical Control (NC) machine with an oil leak is projected on the screen): TPS-C: "Where is the oil leaking from?" Chief supervisor, large machine shop: "This machine is not maintained." TPS-C: "Cleaning the machine is not kaizen, but preventing oil leaks from happening is kaizen. Let's find the cause of the oil leak." (Field notes on a problem follow-up meeting)
Supporting	Problem follow-up sheets are used for conducting kaizen	"We use problem follow-up sheets at the paint shop. We check the 4S situation of this shop, and consider how to improve it using such sheets. After that, I will teach them [frontline employees] what PDCA [Plan Do Check Action] is." (TPS-C)
	Kanban cards are used for managing work-in-progress parts in a JIT manner	A green box with a kanban card, which shows the number of parts that should be contained in the box, is used for managing work-in-progress parts. One box contains only the number of parts required for the post process. (Activity report on the M&A project)
Disconnecting	Pictures sent from the customer focus management's attention on visually clean plant conditions	"When a member of the purchasing personnel [of the customer] goes to a competitor and sees a clean shop floor, he or she always takes a photo and circulates it to other suppliers. It is obvious that such a supplier receives a high evaluation, because it spends money for cleaning the shop floor." (MD)
	Management gets out of the project after the end of the first week	"Quality director [. . .] was supposed to conduct 4S with us, but he stopped joining us after the end of the first week. I could not force him, since he said quality issues should be prioritized." (TPS-C)
	Competing epistemic objects	
Competing objectives	Managers only follow customer requests, and do not understand the effectiveness of 4S	"Managers don't understand our activities [4S]. All they can do is to follow customer instructions. They can neither explain the effectiveness of our activities to the customer, nor that our activities can achieve the results that the customer needs." (TPS-C)
	4S activities are not included in the organizational goals	Project promoter 1: "Frontline supervisors are fully occupied with pursuing their own goals, and there is no time to do other things." Author: "Are 4S activities included in their goals provided by the management?." Project promoter 1: "No."
Competing relations	Frontline employees regard management instructions as useless	Project promoter 2: "I try to meet requests from my boss. I perform my job following my boss's instructions, but it doesn't work. Author: "Why?"

TABLE 3A
(Continued)

Theme	First-Order Codes	Representative Quote Or Description
		Project promoter 2 "My superiors do not put emphasis on 4S. They are only interested in production capacity and quality."
	Managers shift blame to frontline employees	"Team leaders are responsible for this issue. They don't want to use the boxes designed for managing production tools. . . They don't have enough skill to organize the tools." (Production Manager, in discussion with TPS-C, and supervisor on how to manage production tools, during roundtable meeting for the paint shop)
	Lack of collaboration on 4S from the quality division	"She does not use any judgment standards. She does not care a bit about bad 4S situations" (TPS-C in relation to an employee from the quality division who had just routinely measured work-in-progress parts with a caliper. Field notes on the large machine shop)
	Responses to paradox	
Regression to the previous state	Frontline employees are only interested in daily operations, not 4S for further improvement	"I have no idea [about how she can improve her operation]. I think it is good enough already. My operation has become much easier than before. . . I am not interested in 4S." (Operator, small machine shop)
	Frontline employees narrowly focus on production, not 4S	"There is no improved situation at the M&A plant, the painting shop in particular. . .Supervisors focus only on doing production operations. They are not interested in 4S." (Project promoter 1)
	A messy shop floor situation represents regression	"This bad situation cannot be improved, even though we try to correct it. Every day we have to see such a bad situation." (Chief supervisor, warehouse, in response to an image projection depicting a poor plant situation. Field notes on a problem follow-up meeting)

To summarize, across the two cases in this step I identified that a combination of artifacts and social interaction stimulated actors to pay attention to both performance and learning. Guided by practice studies recommending that researchers focus on both social interaction and materiality (e.g., Balogun, Jacobs, Jarzabkowski, Mantere, & Vaara, 2014; Dameron et al., 2015; Schatzki, 2005), I finally aggregated the themes that emerged in this step into the concept of "sociomaterial stimulation."

Step 3: Identification of interplay of material artifacts. In this step, I attempted to identify how the interplay of material artifacts that played specific roles (identified in Step 2) created conditions for the unfolding processes of the transformation projects. From the analysis of the M&A case, first, the theme of "competing objectives" emerged. In this plant, the interplay of artifacts that played the roles of triggering, supporting, and disconnecting led to competing objectives between frontline employees as core members of the M&A project and managerial staff who tried to promote the old 5S system. This interplay also led to "competing relations" between actor groups that pursued different objectives (the second theme). Guided by studies that have linked such organizational issues to the structure of epistemic objects (Knorr-Cetina, 2001; Werle & Seidl, 2015), I further aggregated these themes identified in the analysis of the M&A project into the concept of "competing epistemic objects."

From the analysis of the Die-Casting case, by contrast, the theme of "interrelating objectives" emerged. In this case, the interplay of artifacts that played the roles of triggering, supporting, and connecting led to interrelating objectives between managerial staff and frontline employees. This interplay also led to a situation in which managerial staff and frontline employees became able to recognize the interrelationship between them, to which I attached the label of "fostering

TABLE 3B
Identified Themes and Representative Quotes or Descriptions in the Die-Casting Case

Theme	First-Order Codes	Representative Quote or Description
	Sociomaterial stimulation	
Triggering	Videos trigger interactions for kaizen activities	TPS-C: "Let's write down problems identified through watching the video." Production manager: "One second. I am still sorting out the problems. The hoist's security lock doesn't work" Chief supervisor, equipment shop: "It doesn't ensure the safety of operators." (Field notes on a TPS meeting)
	Use of red tags for identifying problems	"I have learned what we should do is to attach a red tag to a problematic situation. I had never done this before. I have found that we can identify problems quickly by attaching red tags to them." (Chief supervisor, die-casting shop)
Supporting	Painted distribution cables are used for improving changeover operations	"They [frontline employees] painted distribution cables with different colors to prevent themselves from making a wrong connection. I watched how they implemented changeover operations, and was sure this would lead to improvements." (TPS-C)
	Problem follow-up sheets are used for encouraging frontline employees to conduct epistemic activities	"I started to use problem follow-up sheets for cultivating our operators, and encouraged everybody to write down any problem they identified, and countermeasures they conceived. Then I followed up their ideas. . . I started to check problem follow-up sheets provided by them every day." (Chief supervisor, die-casting shop)
Connecting	A 4M analysis tool connects operational problems to SOPs	A 4M analysis tool is used for classifying identified problems into four categories—man, machine, material, and method—after which these problems are dealt with by root cause investigation. This clarifies the importance of SOPs. (Activity report on the Die-Casting project)
	An action schedule connects project activities to a broader project objective	An action schedule is used for making clear when individual project activities (e.g., 4S red-tag practice) are conducted to solve identified problems, through which individual activities are connected to the achievement of a broader target decided by project members. (Activity report on the Die-Casting project)
	Interrelating epistemic objects	
Interrelating objectives	Managers regard 4S as part of organizational objectives	"Now I regard 4S as the core of gemba management. I have started to believe that we cannot make a profit unless we make a serious effort to do 4S." (Production manager)
	Frontline employees understand the importance of 4S for kaizen	Author: "What do you think about the purpose of 4S?" Chief supervisor, die maintenance shop: "I think it is important to implement it every day for making kaizen every day. We implement 4S every day whether there is a customer visit or not."
Fostering interrelationships	Managers give frontline employees opportunities to participate in kaizen	"It is important to drive seiri [organization]-seiton [orderliness] home to gemba people. We have to be persistent in doing seiri-seiton... It is also important to give frontline employees opportunities to participate in team activities for kaizen." (Quality manager)

TABLE 3B
(Continued)

Theme	First-Order Codes	Representative Quote or Description
	Managers respect frontline employees' opinions	"We need to give our team leaders clear goals, but also need to listen to them about what we should do to achieve those goals." (Production manager)
	Improved communication between die-casing and die maintenance divisions	"Interrelationships between different divisions have improved. Previously people shifted responsibility to each other. . . In the case of die repairing, we talk with die maintenance people about how to repair those dies. We are doing such cooperative activities now." (Chief supervisor, die-casting shop)
Responses to paradox		
Persistent acceptance of the paradox	Implementing kaizen based on their own ideas, while maintaining standardized procedures	"In the second [4S red-tag] practice, I had started to try to solve problems on my own before going to TPS-C. . . Now I am trying to make sure that tools should be returned to the original location after use, and that trash should never be thrown away on the shop floor." (Chief supervisor, die maintenance shop)
	Autonomously conducting 4S, while actively providing opinions	"We began to autonomously conduct 4S... I believe that an atmosphere in which we actively provide our opinions about our problems has been created." (Chief supervisor, die-casting shop)
	Clear recognition of improved situations by frontline employees	"I think methods for visual management and how things are located have improved significantly. We have created situations where operators work better, where they can find and use the necessary tools more easily, and where we can improve efficiency with lower costs." (Chief supervisor, die maintenance shop)

interrelationships." Guided by the epistemic objects literature, I further aggregated these themes identified in the analysis of the Die-Casting project into the concept of "interrelating epistemic objects."

Step 4: Identification of actors' responses to the paradox. In this step, I attempted to identify actors' responses to the learning–performance paradox that emerged through sociomaterial stimulation. Regarding identification of the paradox among actors, following Andriopoulos and Lewis (2009), I looked for contradictory statements representing the paradox within the same transcript (e.g., a frontline employee who actively provided ideas for improving SOPs, while also showing disciplined behavior with respect to following SOPs).

In the M&A case, I identified that managerial staff continued to give frontline employees orders in a unilateral way, without offering opportunities for seeking new ideas for improvement. In this plant I also identified that frontline employees, while engaging in activities for performance as well as for learning at the early stage of the project, gradually reverted back to the previous state in which they had narrowly focused on performance, and not on learning. Guided by Lewis's (2000) classification of actors' responses to paradox, I attached the label of "regression to the previous state" to this situation. In the Die-Casting case, by contrast, I identified that managerial staff stressed the importance of ensuring frontline employees' disciplined behavior as well as of giving them opportunities for experimenting and seeking new ideas for improvement. As might be expected, I identified that frontline employees continuously engaged in activities for performance as well as for learning. Guided by Lewis (2000), I attached the label of "persistent acceptance of the paradox" to this situation.

Step 5: Development of a process model. Finally, I integrated data that emerged from the analysis of the

two cases into a process model. The M&A case is shown on the top half of Figure 1, while the Die-Casting case is shown on the bottom half. Both cases clearly show how material artifacts contribute to the process of rendering the learning–performance paradox salient, as well as that of shaping actors' responses to the paradox. In the M&A case, sociomaterial stimulation led to competing epistemic objects that created cognitive, as well as relational, contexts for actors' responses to the paradox, which resulted in the regression to the previous state. In the Die-Casting case, sociomaterial stimulation led to interrelating epistemic objects that created cognitive, as well as relational, contexts for actors' responses to the paradox, which resulted in the persistent acceptance of the paradox.

FINDINGS

The M&A Case

Background conditions. Before TPS-C was hired by C-Maker in December 2014, the M&A plant had promoted the 5S project to meet the strong demand from the main customer. Although lean textbooks have stated that 5S builds a foundation for kaizen implementation (Imai, 1997; Ohno, 1988b), this plant had developed a different understanding of 5S. Managerial staff of this plant gave first priority to creating a visually clean plant that would please the customer. They tried to achieve this goal by strengthening disciplinary control, while expecting little from frontline employees in terms of suggesting ideas for improvement. The MD of the M&A plant noted:

> We have conducted 5S to prepare for customer visits... We have rated 5S performance at each shop. But it has been difficult to gain frontline employees' active cooperation... The major problem of our Chinese factories is the lack of discipline. In China there is no such way of thinking [frontline employees should be disciplined]. I have joined Toyota's plant tour, and thought that we need to learn Japanese people's disciplined attitude.

Frontline employees of this plant also regarded 5S as simply cleaning the shop floor. A frontline supervisor of this plant who was an active project member explained how he conducted the old 5S activities:

> I just ordered cleaning workers to get the shop floor clean when I found a messy place... In those days I was preoccupied with production performance. We were barely conscious of doing 5S on our own initiative. We didn't try to conduct 5S before someone ordered us to do it.

This shows that the old 5S concept is akin to Taylorism, which promotes disciplining frontline employees to ensure efficient performance. One of the purposes of TPS-C's transforming project of the M&A plant (M&A project) was to revise this understanding of 5S, and implement activities that embraced the kaizen concept, or Toyotism. Under this concept, frontline employees are expected not only to follow rules and standards for 5S, but also to create new rules and standards leveraging their ideas. TPS-C intentionally used "4S," which was also used in Toyota Japan to differentiate his project from the old 5S concept. He noted:

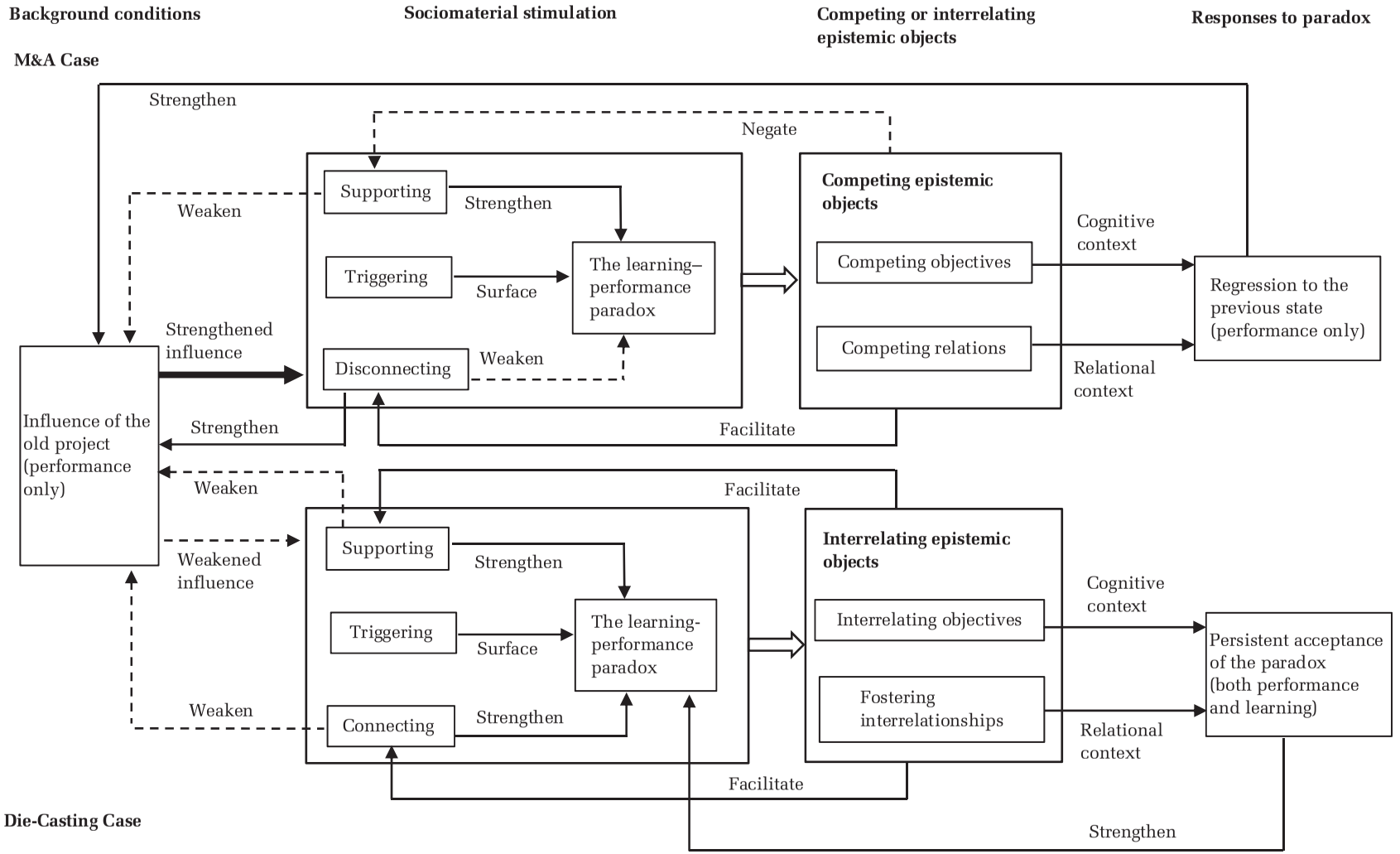
> First of all, I told to the head of the company: "Let's exclude fifth S [Shitsuke, or discipline] from the 5S. Top leaders always stress the importance of disciplining employees... However, if employees are not disciplined, the responsibility lies with the head. It is like a parent who should be responsible for their children's behavior. The point is how to promote 4S in the entire organization, not how to discipline employees.

TPS-C decided that establishing 4S activities that embraced the kaizen concept in the organization was the main objective of the M&A project. The core project members consisted of TPS-C, project promoters 1 and 2, and frontline supervisors at the M&A plant.

Sociomaterial stimulation. The M&A plant had four main shops: large machine, small machine, assembly, and paint. After TPS-C conducted a presurvey in December 2014, he decided to implement a "4S red-tag practice" at the paint shop, whose 4S performance was the worst. In this practice the participants put a red tag on anything identified as problematic in order to take countermeasures. This practice aimed not only at working intensively on improvement of the 4S situation in the short term (e.g., one to two weeks), but also at teaching the participants how to conduct 4S. The quality director, seven supervisors, and project promoters 1 and 2 participated in the first practice, where 214 problematic points were identified from the paint shop. This practice was rotated among different shops so that key supervisors from each of the four shops could engage in the practice and take lessons from TPS-C. TPS-C had a particularly strong expectation that these supervisors should became able to give their subordinates instructions on how to implement 4S and kaizen, and jointly implement 4S on their own initiative.

Through the observation of 4S activities at the M&A plant, I identified two themes on the roles of material artifacts that stimulated actors to focus on

FIGURE 1
A Process Model of Transformation Projects in the M&A and Die-Casting Cases



both performance and learning. The first theme was "triggering," in which artifacts that visually represented problematic situations were used for triggering epistemic activities for taking countermeasures. Red tags attached to items indicating problematic situations were a typical example of the artifacts that played this role. The leftmost picture in Figure 2 shows a red tag attached to an old-type cutting tool that is arranged with those currently used. There is no means of identifying the type. Red tags were also attached to things such as broken and dirty machines or production tools, and different small parts that were mixed up in one box. Project members also took photos of these problematic situations, which played the role of triggering as well. The second picture in Figure 2 shows a forklift that is placed somewhere different from a designated area.

These artifacts that visually represented problematic situations were used in social interactions, such as meetings among project members, in ways that stimulated participants to focus on performance as well as learning. A problem follow-up meeting is an example of such social interactions. In a meeting I observed, project members discussed problematic situations based on pictures of these situations that were projected on a screen using PowerPoint. When a picture was projected that showed a number of urethane pallets for moving products placed outside of the designated area in the warehouse, the following interaction unfolded among TPS-C and project members (bold is used to emphasize relevant passages):

> TPS-C: Look. **These pallets are outside the designated area.**
>
> Chief supervisor, warehouse (CSW): Does this cause a problem?
>
> TPS-C: If you bring these pallets to gemba [shop floor] randomly, gemba people need to sort out these different size pallets.
>
> CSW: **I will fix it immediately after I go to gemba.**

In this conversation TPS-C first directed project members' attention to how randomly placed pallets created unnecessary sorting work on the shop floor. Then, CSW responded to TPS-C by saying "I will fix it," which shows that he paid attention to performance. The conversation continued:

> CSW: These pallets themselves have a problem.
>
> TPS-C: I agree. They are too large to hold these small contents.
>
> CSW: They become deformed because the contents are so heavy.
>
> *Discussion ensues about the problems with these pallets.*
>
> CSW: There is nothing wrong with just finished products. But they become deformed if they don't leave the factory within one month. Some products stay in the factory for two months or even six months.
>
> TPS-C: If you know this, **please think about how to prevent this from happening as a team**. It is the job of chief supervisors.
>
> CSW: I will do so.
>
> TPS-C: Thank you.

Through this conversation, CSW was further stimulated to think about how to prevent the

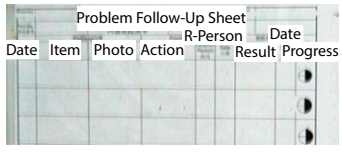
FIGURE 2
Artifacts that Play the Roles of Triggering and Supporting at the M&A Plant

Artifacts that play the role of triggering

A red tag is attached to an old-type cutting tool that is arranged with those currently used

A picture showing that a forklift is left unattended in a location other than that designated on the shop floor

Artifacts that play the role of supporting



A problem follow-up sheet used for highlighting the progress of problem-solving activities

Yellow lines clearly designate the areas for storing parts boxes

problem of the deformation of pallets (see emphasis). TPS-C, instead of giving clear instructions to CSW, provided opportunities for him to create his own solutions to the problem, or directed his attention to learning. CSW actually created a first-in first-out system at the warehouse to reduce the storage period for finished products to the greatest extent possible.

Aside from the artifacts that were used for triggering such social interactions, I identified another type of artifact that played the role of "supporting" the implementation of the transformation project (or kaizen activities). The rightmost picture in Figure 2 shows yellow lines that clearly designate the areas for storing parts boxes. Frontline employees at the paint shop painted this line after identifying the problem of parts boxes that had been placed randomly on the shop floor during the first red-tag practice. This line was designed to clarify rules and standards, through which actors easily identified problems, and took countermeasures.

The third picture in Figure 2 shows a problem follow-up sheet that highlights the progress of problem-solving activities. When project members (mainly project promoters) identified a problematic situation, they attached a photo of the problem to a problem follow-up sheet with a short comment, or just sent a photo with a comment to a supervisor via e-mail. Subsequently, the supervisor of the shop where the problem was identified had to complete a problem follow-up sheet by filling in the columns of action, person responsible, start and finish dates, progress and result. This sheet was designed to create opportunities for actors to engage in kaizen activities, as well as making clear the progress of these activities.

In the M&A project, although frontline supervisors were actively involved in the aforementioned project activities, managerial staff had stepped away from the project. After the end of the first red-tag practice, which lasted one week, the quality director dropped out of the project. There was no active participation from the key managers of the M&A plant (the MD and quality director who organized the overall production and quality activities) after the quality director left. Through further analyzing the M&A project, I identified that some artifacts played the role of "disconnecting" managerial staff from the project. These artifacts included key performance indicators (KPIs) and 5S scores given by the main customer, which directed managerial staff's attention to the old 5S concept. The following quote by the quality director shows how seriously the managers of this plant took these artifacts:

> [Name of customer] gives us KPIs every three months. . . A supplier quality engineer from the customer visits us more than three days a week. They come to us almost every day. We are one of its main suppliers. . . They give our 5S situations a grade. Our plant will be graded "A" when we get higher than 90 points, and "B" when we get higher than 80 points.

As this quote shows, customer quality engineers frequently visited this plant to check KPIs and 5S scores, and actually placed many demands on managers to ensure visually clean and organized plant conditions. This situation made them preoccupied with dealing with the customer demands and conducting the old 5S activities, while taking their attention away from 4S and kaizen promoted by TPS-C. TPS-C expressed displeasure over this situation:

> The customer frequently makes a request: "Do it like this; Do it like that; and implement this parts sorting method." They [managerial staff] don't understand why they need to do so. They are just pulled in a dozen different directions from the customer. . . They are occupied with customer requests, and leave my requests until later.

Competing epistemic objects. Following my analysis of the roles of material artifacts described above, I analyzed how the interplay of these artifacts created conditions for the unfolding process of the M&A project. Through my analysis, I identified that the interplay of artifacts that played the roles of triggering, supporting and disconnecting led to competing understandings of organizational objectives between managerial staff and frontline employees. Guided by the theory of epistemic objects (Knorr-Cetina, 1997; Rheinberger, 1997), I defined such an interplay as "competing epistemic objects." This concept consisted of two second-order themes.

The first theme was "competing objectives" between frontline employees as active members of the M&A project and managerial staff who tried to promote the old 5S system. In fact, the managerial staff had recognized the great effects 4S activities promoted by TPS-C had. For example, the MD of this plant explained:

> After finishing a red-tag practice at one shop, they [frontline employees] gave a presentation in front of me. I found how cleanly they placed products. They also created beautiful display boards. I thought how easily operators can find the right tool. This increases our work efficiency.

However, managerial staff at this plant appreciated frontline employees' 4S activities simply because

they had improved customer 5S scores, not because they had provided their own ideas. The managerial staff continued to try to promote the old 5S system by putting emphasis on disciplinary control, such as imposing fines on those who could not achieve the target scores. TPS-C complained about such a management style:

> This plant conducts 5S activities as a contest. Winners will be rewarded, but losers will be fined. . . The MD is interested only in a bid on a contract to supply parts to the customer [e.g., KPIs and 5S scores that significantly affect the bid], not in gemba [frontline employees' activities conducted on the shop floor] at all.

This situation increased opportunities for frontline employees to focus on performance, while decreasing opportunities for them to focus on learning. For example, the MD did not include frontline employees' use of problem follow-up sheets in the annual plant policies, though TPS-C strongly recommended them to use the sheets as part of the M&A project. This actually decreased opportunities for frontline employees to use these sheets. By July 2015 all the four main shops of this plant had implemented a red-tag practice at least once, which meant that key supervisors at these shops had already been aware of how to use a problem follow-up sheet. During my observation of the M&A plant in September 2015, however, I identified that problem follow-up sheets showing that problems had not yet been solved remained untouched on a bulletin board at the large machine shop. When I asked a supervisor at this shop, who was an active project member, "Why don't gemba employees use problem follow-up sheets?" he lamented:

> There are so many problems that we can't use these sheets. Our monthly checklists are kept intact. . . Our chief supervisor has already got used to this situation. He only points out the problem, but does not provide specific guidance for improvement... though I still want to detect the cause of problems, and continuously solve the problems.

The second theme related to competing epistemic objects was "competing relations." I identified competing relations shaped by the interplay of artifacts between frontline employees who committed themselves to the M&A project and managerial staff who committed themselves to the old 5S system. Competing relations was exemplified by relations between the quality division led by the quality director and the frontline employees in the production division who actively promoted the M&A project. The quality director who was preoccupied with customer-given KPIs and 5S scores strongly promoted the old 5S activities. This directed project promoter 2's attention to the old 5S checking method. In fact, she was assigned by TPS-C the task of regularly checking the 4S situation of the M&A plant. However, she belonged to the quality division, and stressed the importance of pleasing the customer as the main objective of "4S activities." TPS-C lamented her lack of understanding of the objective of 4S activities:

> She [project promoter 2] deems herself as a person in charge of old 5S activities. When she goes to the shop floor to check 4S, she gives a false impression [on 4S] to gemba people. . . Her superior is in charge of ISO9000, and does not know anything about 4S, but gives instructions to her.

The 4S check conducted by her rendered competing relations between the quality and the production division salient. A supervisor at the large machine shop expressed displeasure over the old 5S checking method:

> I thought the old 5S check practice was unfair. The checkers only scratch the surface of the problem. On a day when a 5S check will be conducted in the afternoon, people only do the cleaning in the morning. The situation reverts back [to the previous bad condition] the next day. . . I thought such superficial evaluation was unfair.

The frontline employees who were active project members like him tried to conduct 4S activities (e.g., using problem follow-up sheets), while managerial staff ordered their subordinates to ensure visually clean plant conditions (i.e., the old 5S system). In such a situation, the active project members received less and less support from their colleagues. The same supervisor explained:

> What a tough predicament. I have to conduct 4S all by myself. Nobody tries to help me. I don't want to conduct 4S on my own. My colleagues are not interested in 4S... Here, there is no feeling that we take a collaborative approach to conducting 4S.

Regression to the previous state. Finally, I analyzed actors' responses to the learning–performance paradox that emerged through sociomaterial stimulation. The set of images in the top half of Figure 3 shows the conditions of the M&A plant around early 2015. At that time frontline employees, through participating in project activities, actively engaged in identifying problems, taking countermeasures, and establishing new standardized procedures. For example, after they cleaned and tidied up the shop floor thoroughly, they created standardized procedures that indicated where things should be placed and how these should be kept on the shop

FIGURE 3
4S Situations of the M&A Plant

Plant conditions around early 2015

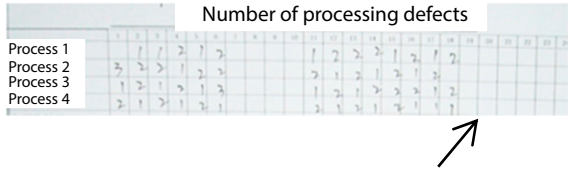
Plant floor: Trash and unneeded items have been completely removed from the plant floor. The floor has also been cleaned up thoroughly. (Paint shop, M&A plant)

Area for storing parts boxes: The designated areas are clearly highlighted by yellow lines. Display cards on the wall indicate the parts that are put in the boxes, and what these parts are for. (Paint shop, M&A plant)

Shelf for storing production tools: Different tools are sorted out. Each tool is put into a box labeled the tool number. (Toolhouse, M&A plant)

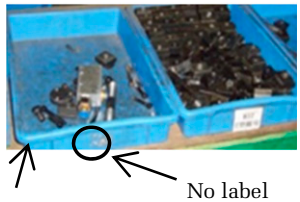
Plant conditions around early 2016

Plant floor: Plant floor is stuffed with unneeded items and boxes containing surplus parts. (Paint shop, M&A plant)



Blank after February 18, 2016

A table showing the number of processing defects: Frontline employees stopped counting the number of defects after February 18, 2016. This picture was taken on February 28, 2016. (Small machine shop, M&A plant)



Small boxes for storing production tools: Different tools are mixed together in a box with no label. (Toolhouse, M&A plant)

floor, such as making the areas for placing things clear using painted lines (upper left and middle images in Figure 3). They also created a shelf for storing small machining tools that clearly showed what tool should be stored in which box (upper right image in Figure 3). These images show that frontline employees at the M&A plant fixed shop floor problems (performance), and created new standards and countermeasures (learning) just after conducting a 4S red-tag practice.

However, instead of sustaining these conditions and activities, the employees actually became less and less inclined to do so. The image in the upper left of Figure 3 shows the situation of the paint shop just after the first red-tag practice (around early 2015), while the image on the lower left shows the situation

in the same place about one year later, in which unneeded and unsorted items were piled up high on the shop floor. This figure also shows that around early 2016 frontline employees neither followed the procedure on a check sheet (the lower middle image in Figure 3), nor followed the procedure on machining tools (lower right image).

To summarize, Figure 3 shows that the learning–performance paradox emerged just after implementation of the 4S red-tag practice, while undergoing "regression" afterward. Managers in this plant continued to put emphasis on disciplinary control, with little emphasis on frontline employees' activities for learning. For example, the MD, when he received customer requests, called managers and chief supervisors via WeChat (a smartphone app) and gave instructions to frontline employees in a unilateral way. Such calls occurred frequently, which deprived employees of opportunities to engage in TPS-C's 4S activities. During one problem follow-up meeting I observed, most of the participants frequently looked at their smartphones. Some of them asked TPS-C's permission to leave the meeting on the grounds of dealing with customer requests, and went back to their workplace. TPS-C was disappointed with their negative attitude toward 4S and kaizen: "In this plant the MD issues instructions by WeChat. Everyone always depends on WeChat. They only wait for his instructions sent by WeChat."

The attitude of just trying to follow management instructions shows that frontline employees had lost motivation for learning, and acted in line with the idea of Taylorism. This was evidenced by a quote given by an operator at the tool house. He regularly maintained cutting tools, and even had a desire to improve his operational skill through participating in 4S activities; however, he was frustrated at the situation where there was no opportunity for him to participate in such activities, which directed his attention to performance alone, not learning. He noted:

> I have not participated in 4S activities. These activities cannot be done individually. So full participation from the employees of my shop is needed. But there is no opportunity to participate in these activities... I don't talk about problems related to my operations to my supervisor... I take my assigned job seriously, but don't give kaizen ideas to my boss.

TPS-C gave me the following opinion about the M&A plant, which shows that frontline employees had given up implementing kaizen:

> At the M&A plant, "doing 4S for JIT" has been all but forgotten... The paint shop has implemented 4S [red-tag practice] three times. But now there is no improved situation... The biggest problem is that they gave up before finding a way for improvement.

The Die-Casting Case

Background conditions. In September 2015, C-Maker moved its die-casting plant to a new location about a mile away from the M&A plant. At that time TPS-C was asked by the president to mainly be in charge of the die-casting plant, while regularly visiting the M&A plant to check the progress of its project activities. Managerial staff and frontline employees of the die-casting plant had engaged in the old 5S project, and developed a similar understanding of 5S to that of M&A plant members. For example, a production manager of the die-casting plant noted: "We had implemented 5S so far. But we had only focused on superficiality, got the gemba organized, and visually cleaned." A frontline supervisor of this plant also remarked: "I think that the old 5S was nothing other than a slogan. We just tried to clean up the shop floor quickly." A quality manager gave the following explanation about the old die-casting plant that embraced the idea of Taylorism (strong performance orientation):

> The old factory didn't have the right conditions for implementing the JIT system. All the plant members from top to bottom focused exclusively on quickly finishing our production operations, and increasing sales.

The transformation project of the die-casting plant (Die-Casting project) began with the implementation of 4S activities. The core project members consisted of TPS-C, project promoter 1 (while project promoter 2 continued to be in charge of the M&A project), three frontline chief supervisors (die-casting, die maintenance, and equipment), and a production and quality manager. At this plant, during my research, there was no MD or quality director, these two roles were filled by the production (die-casting) and quality managers. By the time TPS-C was asked to be in charge of the die-casting project, he had clearly recognized the difficulty of sustaining 4S activities at the M&A plant, and the importance of involving key managers in the project. TPS-C agreed to be in charge of the die-casting project under the condition that all project members, including managers, would fully participate in project activities. He thought the

participation of managers was critical for conducting problem analysis, because it would be difficult for supervisors who had limited authority to deal with most of challenges identified through the analysis without the aid of managers. TPS-C also asked the company to prepare a dedicated meeting room (called the TPS meeting room) for conducting analysis activities.

Sociomaterial stimulation. After TPS-C conducted a plant investigation with project promoter 1, a 4S red-tag practice began in October 2015. Just like the M&A plant, red tags and pictures that played the role of "triggering" were used for visually representing problems, such as die-casting machines with greasy dirt, production tools that were not regularly maintained, and bolts and nuts that were randomly placed on work tables. In this project, video-recorded changeover operations were also used for visually representing problems among project members. I observed a project meeting (called the TPS meeting) in which project members identified problems by watching video-recorded changeover operations projected on a screen. Based on the video, they discussed the identified problems to detect the root cause of the problems. I observed the following social interaction among TPS-C and project members:

> TPS-C: Let's go to the next problem. **Why do they [operators] throw production tools on the floor?**
>
> Chief supervisor, die-casting (CSD): **They are less disciplined**. They have bad habits.
>
> TPS-C: Who is responsible for disciplining them?
>
> CSD: Their parents are half responsible. We, supervisors are half responsible.
>
> PM (Production manager): We have not provided enough training to supervisors.
>
> CSD: This is because I have not been trained so far. I have not understood how to do that.
>
> TPS-C: You get the point. Then, why haven't you understood this?
>
> Chief supervisor, equipment (CSE): We work 12 hours every day. There is no time for training.
>
> TPS-C: Why don't they understand? Why aren't they trained? Here, there were no rules, and no training method. Senior colleagues at Toyota gave me training many times.
>
> CSD: I don't have a good understanding of bars and bolts. I am not clear about what wrench should be used for this bolt.
>
> *Discussion ensues about the bars.*
>
> TPS-C: Let's try 4S again. **You can create rules on how the tools are organized.**

This conversation shows that the video was first used for "triggering" social interaction by visually representing the problem in which operators threw production tools on the floor. Then, CSD was stimulated to recognize that this problem was caused by the lack of discipline among frontline operators (issues related to performance). TPS-C further asked related questions to stimulate participants to pursue the root cause of the problem, which led to CSD coming up with ideas about the causes of the problem. Finally, TPS-C offered to conduct a 4S red-tag practice for creating new rules for the management of production tools (learning).

Through conducting 4S red-tag practices, participants actually created new standards and rules to ensure a better 4S situation at this plant. These standards and rules were highlighted by artifacts, such as painted lines on the shop floor that clearly distinguished aisles from operating areas, colored cards that clearly distinguished dies that needed to be repaired from those that had been repaired, and SOPs that described newly developed operating procedures. These artifacts made it easier for plant members to identify problems to be solved, which created opportunities for conducting further kaizen activities. These artifacts, therefore, played the role of "supporting" implementation of the transformation project. In the Die-Casting case, team leaders and operators actually participated in 4S red-tag practices, and contributed to creating these artifacts. In the second practice, conducted in November 2015, the participants of the first practice (i.e., core project members) became instructors, and jointly identified problems and conceived countermeasures with team leaders and operators.

The final theme on the role of material artifacts I identified through analysis of the Die-Casting project was "connecting." The artifacts that played this role included sticky notes, lists, tables, and graphs used for problem analysis, which helped actors connect issues they faced or activities they engaged in to a broader objective related to the project. As for the objective of the Die-Casting project, TPS-C tried to avoid the situation in which plant members regarded implementing 4S itself as the end goal of the project. At the initial stage, he clearly explained to project members that the main objective of the Die-Casting project was to implement TPS–JIT-based die changeover operations. After twice conducting a 4S red-tag practice, the focus of the project activities

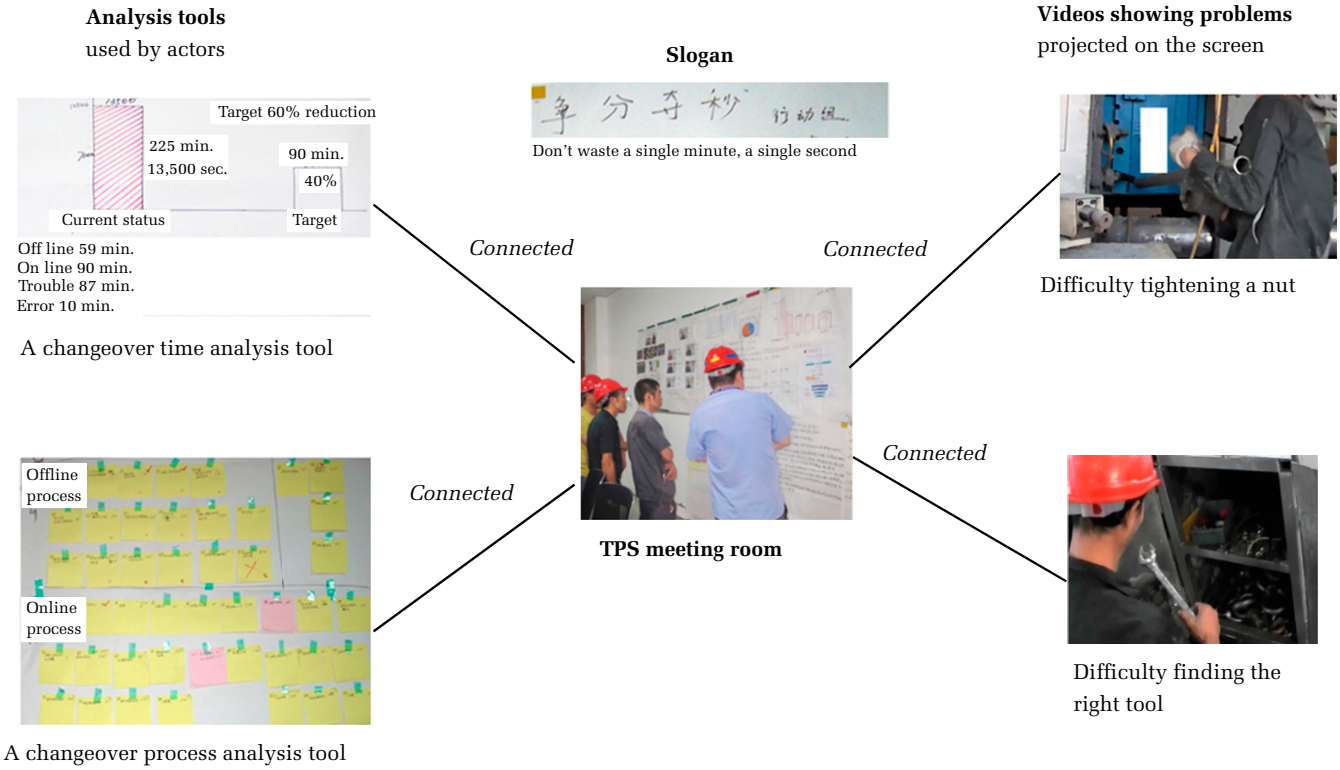
shifted toward the improvement of changeover operations.

The first changeover trial was conducted at an 800 ton aluminum die-casting machine on January 11, 2016. Just after this trial, which took 13500 seconds (225 minutes), core project members jointly decided the target of reducing changeover time to less than 5400 seconds (90 minutes) with the slogan: "Don't waste a single minute, a single second." The target and slogan were posted on the wall of the TPS room. In this room, project members not only watched video-recorded changeover operations for identifying problems, but also conducted problem analysis using analytical tools. Figure 4 shows how artifacts that played the role of connecting helped project members connect the identified problems to a broader objective related to the Die-Casting project. The two images on the right in Figure 4 show examples of problems identified through watching videos. These problems were first listed on a whiteboard, and then each of them was written down on a sticky note. These sticky notes were further classified into issues regarding the offline changeover process and the online process using a changeover process analysis tool (on the bottom left of Figure 4). These classified problems were further analyzed using a changeover time analysis tool (on the top left of Figure 4), through which the current status of changeover time was connected to the target time (90 minutes).

I observed a TPS meeting on March 2, 2016 (almost two weeks after the second trial, where it took 7,220 seconds), in which members conducted problem analysis using a changeover process analysis tool and a changeover time analysis tool. The following conversation in this meeting shows that the problems identified as issues related to the offline process were connected to the target of the project (relevant passages emphasized in bold).

> TPS-C: Let's classify 24 problems we identified into the issue of the offline process and that of the online process.
>
> *Project promoter 1 reads out problems listed on the whiteboard one by one. Project members respond to him by saying "offline" or "online," which he adds to the whiteboard.*
>
> TPS-C: **50% of 7,220 seconds was caused by the issue of the offline process. That prevented us from achieving the target.** Who is in charge of the offline process?

FIGURE 4
Artifacts that Play the Role of Connecting



TPS-C looks toward production manager (PM). PM looks uncomfortable.

TPS-C: Don't let it get to you like that. In the first place, the problem was that we have not decided how to conduct offline changeover processes. Let's eliminate the problems of the offline process, and do the next trial. Currently we have a lot of problems on the management of the offline process.

Conversation moves to the topic of problems related to the offline process.

Chief supervisor, die-casting (CSD): There is also no area for storing nuts during changeover operations

TPS-C: Please recall the purpose of 4S.

CSD: Eyebolts disappear quite often.

TPS-C: If it is so, we need to clean up the mess. Is the condition of this wrench OK? It looks so difficult to tighten the nut using this wrench. The purpose of 4S is to create a situation where we can use tools immediately when we want to use them.

CSD: We can use this wrench.

TPS-C: The problem is not whether we can use this tool or not. We need to keep this tool always at the ready. You need to think about the problems of gemba more seriously. We need to get cooperation from gemba people. I would like all of you to learn the importance of 4S. **A bad 4S situation prolongs changeover time**. **Please consider countermeasures with gemba people. Please decide rules and methods for the offline process together**.

The above conversation shows that problems related to the offline process were further connected to 4S activities (see text in bold). After the meeting, project members actually conducted a 4S red-tag practice with other employees, through which project members conceived a new procedure for organizing tools used for changeover operations (e.g., nuts and eyebolts) where a dedicated toolbox was used. Then, CSD established a new SOP for changeover operations that incorporated this procedure.

Interrelating epistemic objects. As for the interplay of material artifacts in the Die-Casting project, I identified an opposite pattern from that of the M&A project. In the analysis of this project, I identified that the interplay of artifacts that played the roles of triggering, supporting, and connecting led to interrelating understandings of organizational objectives between managerial staff and frontline employees. I attached the label of "interrelating epistemic objects" to the interplay I identified. This concept consisted of two second-order themes.

The first theme was "interrelating objectives" between managerial staff and frontline employees. At the die-casting plant, both actor groups became able to recognize that activities they engaged in and their organizational objectives were interrelated. As explained in the "Background conditions" section, plant members used to focus on creating visually clean plant conditions in the old 5S activities. After the launch of the Die-Casting project, however, frontline employees began to recognize how conducting 4S on the shop floor contributed to achieving their organizational objectives. For example, a team leader of the die-casting shop explained how conducting 4S contributed to the reduction of changeover time:

> We have reduced changeover time by half. [In relation to how the improvement relates to 4S,] we do 4S every day. . . I have got motivated to do 4S because I became able to see the effect clearly. I have understood that we can reduce changeover time if we better prepare for it [through conducting 4S].

Furthermore, the following quote shows that the CSD had recognized the interrelation between 4S and the objective of JIT implementation:

> The aim of 4S is to lay the foundation for JIT, such as health and safety, and getting the gemba organized. 4S allows us to improve quality as well as productivity. I believe we can reduce changeover time to 90 minutes if we implement 4S thoroughly.

Managerial staff at this plant had also shifted their focus from "5S" to "4S," and begun to recognize how frontline employees' 4S activities and their organizational objectives (e.g., TPS–JIT implementation) were interrelated. The quality manager explained that 4S and other project activities were all linked to TPS implementation:

> We need to do clean up and tidying up over a long period. It takes a long time to change the attitude of chief supervisors. I think we should move our project activities forward. These activities are all connected to TPS. 4S is connected to our current activities. My current understanding of 4S differs greatly from my previous one.

The second theme related to interrelating epistemic objects was "fostering interrelationships," in which managerial staff and frontline employees became able to recognize the interrelationship between them. As already mentioned, managers at the die-casting plant, before implementing this project, embraced the idea of

Taylorism and believed that frontline employees should just follow SOPs created by them. However, as the project progressed, they began to rely on frontline employees' capabilities to solve shop-floor problems and create SOPs. The quality manager noted:

> Previously management did not believe that our employees can create SOPs, and made them just follow the SOPs created by us. Now we have become confident in our supervisors. They can create SOPs by themselves.

Managers at this plant had also begun to create opportunities for frontline employees to conduct activities for learning, such as seeking new ideas and conducting problem analysis. For example, they provided an opportunity for frontline employees other than the project members, such as team leaders and operators, to watch video-recorded changeover operations. The production manager of the die-casting division invited such frontline employees to the TPS room, and showed part of the video-recorded first changeover trial that took 13500 seconds (225 minutes). He then said to them: "It is not your fault, but our fault. It is because we did not create good standardized procedures. Please work together. Our plant will surely be better." The production manager actually worked together with these employees in 4S red-tag practices, and jointly identified problems as well as conceiving countermeasures for the problems.

The aforementioned change in management approach to frontline employees had also fostered the interrelationship among frontline employees. They became more active in learning from each other. A team leader of the die-casting shop explained:

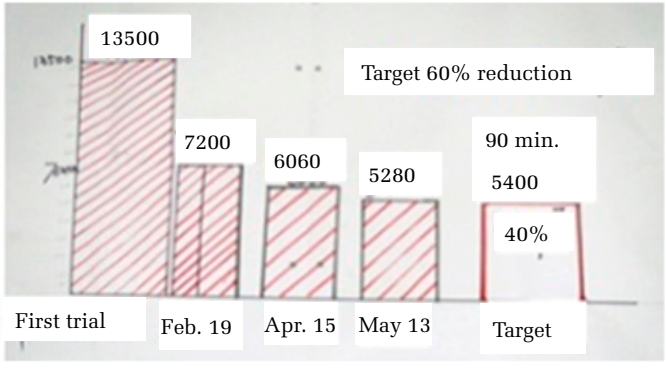
> In our shop bosses and workers started to deal with issues on gemba in a collaborative manner. Then, my operators started to accept my instructions positively. . . In the face of difficulty, we started to listen to each other, and learn from each other.

Persistent acceptance of the paradox. In the Die-Casting case, actors' responses to the learning–performance paradox differed greatly from those of the M&A case. Before the focus of project activities shifted toward the improvement of changeover operations (at the end of 2015), this plant followed a similar pattern to the M&A plant: the 4S situation improved just after conducting a 4S red-tag practice, but then reverted back to a previous state. However, the 4S situation began to gradually improve after the shift of the project focus, through which operational performance also gradually improved. As the graph on the left of Figure 5 shows, the changeover time that took 13,500 seconds (225 minutes) at the first trial was reduced to less than 5400 seconds (90 minutes) by the fourth trial. The number of defects just after the changeover also decreased from 26 on January 11 to seven on May 25 (see graph on the right of Figure 5).

Figure 6 shows that the problem of randomly placed production tools had been fixed (the issue of performance shown on the left) through ideas conceived by project members (learning). Then, a new procedure using a dedicated toolbox began to be used (on the right in Figure 6). Figure 7 further illustrates the improvement of the 4S situation of the die-casting plant, from the dirty and messy situation at the first trial on January 11, 2016 (on the left) to the clean and organized situation at the fifth trial on May 20, 2016 (on the right). These figures evidence that

FIGURE 5
Graphs Showing the Improved Situations of Die Changeover Operations

A graph showing the reduction in changeover time



A graph showing the reduction in the number of defects

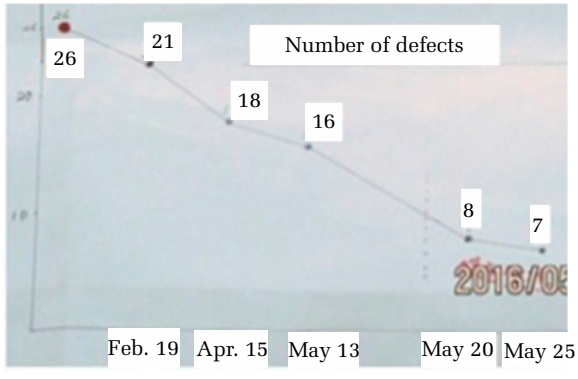
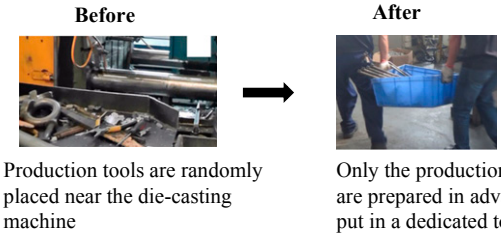


FIGURE 6
The Situations of Changeover Tools at the Die-Casting Plant



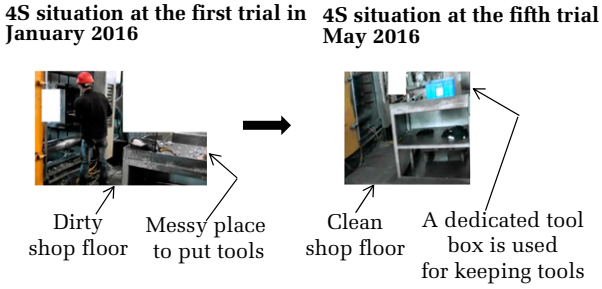
frontline employees at the die-casting plant had implemented kaizen in a sustainable manner. The sustainability of the project was also evidenced by the expansion of changeover analysis activities to other machines (from 800 to 1600 tons), and other processes (from aluminum to zinc). In the 800 ton machines, the CSD became a qualified instructor, and conducted problem analysis with team leaders and operators at the TPS room. As a result, these lower-level employees became able to create SOPs on their own, which led to the achievement of higher performance than that of core project members (e.g., changeover time was reduced to 4440 seconds (74 minutes) on May 25).

Managers at this plant had recognized the importance of giving frontline employees learning opportunities. The quality manager noted:

> I think we need to give our employees more opportunities for participation. We should create our kaizen theme having more input from everyone. I think it's great. We should engage in kaizen all together.

However, they also stressed the importance of ensuring frontline employees' disciplined behavior. The production manager explained:

FIGURE 7
4S Situation Around a Die-Casting Machine at the Die-Casting Plant



> Now I have formed the opinion that what I should do is to prevent the same problem from happening again… So far when gemba operations caused delay, I only asked my subordinates the reason why the delay happened. Now I try to assume a strict attitude, and make them follow company rules.

At the frontline level, I found evidence that frontline employees had *accepted* the learning–performance paradox. For example, the CSD stressed the importance of ensuring employees' disciplined behavior by saying: "I have understood the importance of Shitsuke (discipline). The more operators are disciplined, the more production capacity of our shop floor is increased." At the same time, he stressed the importance of exploring new ideas with his subordinates. He further explained:

> For example, when a problem emerged on the shop floor, and my operator came to me to ask about the problem, I began to ask the question back to him: "Why did the problem happen?"… Now my operators have begun to provide their own ideas like "This might cause the problem. Why don't we take this countermeasure?"

I also found other evidence from lower-level frontline employees. The following quote from a skilled operator shows that the operator had actually provided his own ideas for improving the changeover operations, and created SOPs based on his ideas:

> Operator: I provided an idea of wiping down the top side of the die as a precautionary measure. It is slippy and dangerous if the top side is oily. So it is better to check the top side and wipe off the oil before doing the operation.
>
> Author: Did you incorporate this idea into the SOPs?
>
> Operator: Yes, I did so. I recognize the importance of "safety first."

At the same time, the same operator explained that he had recognized the importance of keeping 4S rules after he participated in a 4S red-tag practice. He noted: "I started to have an idea that we should autonomously follow 4S rules." The Chief supervisor, die maintenance explained that his employees had begun to autonomously conduct 4S:

> Previously we cleaned up our shop floor only just before the visit of our customer. But now we do clean up every morning. Our mindset has changed because our shop floor has become clean. Our team leaders

take a lead in cleaning up. Previously I forced them to do that. But now they do that on their own initiative.

A Process Model of Transformation Projects in the M&A and Die-Casting Cases

Through integrating the themes and aggregated concepts described above, I developed a process model, as shown in Figure 1. The upper side of this figure shows the M&A case leading to regression to the previous state, while the lower side shows the Die-Casting case leading to actors' constant acceptance of the paradox. Both plants, before initiating the transformation projects, had promoted the 5S project that embraced the idea of Taylorism. At the initial stage, both plant members were strongly influenced by this idea, and focused narrowly on performance rather than on learning. However, as shown in Figure 1, these plants underwent different transformation processes, which were divided into three phases: sociomaterial stimulation, competing or interrelating epistemic objects, and responses to paradox. In the following section, I will first explain the M&A case focusing on the three phases.

The M&A case. The sociomaterial stimulation phase is related to micro-level interactions in which actors engage in everyday practice with material artifacts (Lê & Bednarek, 2017; Schatzki, 2001). During this phase, actors at the M&A plant used artifacts that played the role of triggering. These artifacts included red tags and pictures that triggered social interaction through visually representing problematic situations (Knorr-Cetina, 2001). Such social interaction allowed actors to pay attention to both performance (e.g., the necessity of fixing problems) and learning (e.g., the necessity of creating new procedures), or socially construct the learning–performance paradox (Jarzabkowski & Lê, 2017; Sheep, Fairhurst, & Khazanchi, 2017).

During the same phase, actors also used artifacts that played the role of supporting implementation of the transformation project, which included painted lines, labels, and problem follow-up sheets. The supporting role made it easier for actors to engage in project (or kaizen) activities, which strengthened the presence of the learning–performance paradox, while weakening the influence of the old 5S project. In the M&A case, however, some artifacts played the role of disconnecting managerial staff from the project. These artifacts included KPIs and 5S scores given by the plant's main customer. The M&A plant supplied complete products to the customer, which created a situation in which managers of the plant received strong demands from the customer. These artifacts directed their attention to the 5S system, which strengthened the influence of the old project while weakening the presence of the learning–performance paradox.

The competing epistemic objects phase is related to organizational- (or macro-) level conditions or contexts shaped by the interplay of artifacts that play multiple roles, in which actors develop knowledge and understanding (Knorr-Cetina, 2001; Werle & Seidl, 2015). Such conditions are closely linked to the aforementioned micro-level interactions, as these interactions are consequential at a wider organizational level (Jarzabkowski & Lê, 2017; Lê & Bednarek, 2017). Competing epistemic objects are created based on the interplay of social interactions using artifacts that play multiple roles. During this phase of the M&A case, the interplay of artifacts that played the roles of triggering, supporting, and disconnecting led to actors' competing understandings of organizational objectives. Managers of this plant who were stimulated by the artifacts that played the role of disconnecting continued to regard the old 5S activities as the main part of their organizational objectives. For them, these artifacts acted as partial objects that represented the incompleteness of the overall epistemic object (Knorr-Cetina, 2001; Werle & Seidl, 2015), or ensuring visually clean plant conditions for pleasing the customer. At the same time, frontline employees, as active project members, were stimulated by the artifacts that played the role of triggering to focus on both performance and learning. For them, these artifacts acted as partial objects that motivated them to pursue 4S activities as the main part of their organizational objectives.

In such a situation, these different actor groups developed competing understandings of artifacts that played the role of supporting. For example, the managers disregarded using problem follow-up sheets by frontline employees, because such artifacts did not act as partial objects for the managers. By contrast, the same artifacts acted as partial objects for the frontline employees as active members of the M&A project. However, the managers always tried to focus frontline employees' attention narrowly on performance, which made them become aware of the difficulty of using these sheets, or conducting activities for learning. The same was true for other artifacts, such as painted lines and labels that highlighted 4S rules and standards. The managers tried to use these artifacts only for disciplining frontline employees, not for creating opportunities for learning.

During the same phase, the interplay of material artifacts also led to competing relations between

frontline employees who committed themselves to the M&A project and managerial staff who committed themselves to the old 5S project. In this situation, the frontline employees received less and less support from the managers toward kaizen implementation. However, frontline employees in general have limited authority to access company resources, which makes it inherently difficult for them to implement kaizen on their own. Frontline employees at the M&A plant, therefore, had to address the learning–performance paradox in an inherently difficult situation, which might easily have made them feel anxious, and fueled their defensiveness (Lewis, 2000; Vince & Broussine, 1996). This situation made it more difficult for them to use artifacts for learning purposes (e.g., problem follow-up sheets). The interplay of artifacts seen in the M&A case, therefore, negated the supporting role of artifacts, while facilitating the disconnecting role.

To summarize, the competing epistemic objects gave frontline employees a realization of the difficulty of conducting activities for learning (i.e., creating a cognitive context), while also creating a relational context for eliciting actors' defensive responses to the learning–performance paradox. At the M&A plant, frontline employees actually engaged in kaizen focusing on both performance and learning just after a 4S red-tag practice (shown at the top of Figure 3). However, these organizational contexts made frontline employees less willing to implement kaizen (shown at the bottom of Figure 3), which resulted in regression to the previous state in which frontline employees focused exclusively on performance, and not on learning. This situation strengthened the influence of the old project that embraced the idea of Taylorism, which in turn made it even more difficult to transform the organization in ways that embraced the learning–performance paradox.

The Die-Casting case. I will now explain the Die-Casting case. Actors at this plant also used artifacts that played the role of triggering, such as red tags, pictures, and videos, during the sociomaterial stimulation phase. Just like the M&A case, these artifacts were used in social interaction in ways that stimulated actors to focus on both performance and learning, and therefore rendered the learning–performance paradox salient. During the same phase, actors also used artifacts that played the role of supporting, such as painted lines, colored cards, and SOPs. As with the M&A case, these artifacts contributed to strengthening the presence of this paradox, while weakening the influence of the old project.

Managers of the die-casting plant, as in the M&A case, received KPIs and 5S scores from the main customer. Although customer quality engineers frequently visited the die-casting plant, their demands did not seem to be as strong as those the M&A plant received, because the die-casting plant supplied interim products to the M&A plant, rather than complete products to the customer. In fact, the production and quality managers sometimes had to slip out of a project meeting to deal with customer demands. In such a situation, TPS-C suspended the meeting and restarted it after these managers came back. At the die-casting plant, therefore, the KPIs and 5S scores did not play the role of disconnecting. Instead, actors, including managers and frontline employees, used artifacts that played the role of connecting. Such artifacts included sticky notes, lists, tables, and graphs that were used for problem analysis, through which issues actors faced or activities they engaged in were connected to a broader objective related to the project (see Figure 4). By doing so, these artifacts contributed to strengthening the presence of the learning–performance paradox (or kaizen implementation as the main project objective), while weakening the influence of the old 5S project.

During the interrelating epistemic objects phase, the interplay of artifacts that played the roles of triggering, supporting, and connecting led to actors' interrelating understandings of organizational objectives. Both managers and frontline employees at the die-casting plant used artifacts that played the role of connecting, through which problematic situations visually represented by the artifacts that played the role of triggering (e.g., images shown on the right in Figure 4) were connected to a broader organizational objective (e.g., kaizen or TPS–JIT implementation). Here, these artifacts acted as partial objects (Knorr-Cetina, 2001; Werle & Seidl, 2015), which motivated both managers and frontline employees to pursue 4S activities, or focus on performance as well as learning. The interplay of artifacts further allowed both actor groups to understand that 4S activities were interrelated with the objective of TPS–JIT implementation.

The interplay of artifacts also fostered the interrelationship between these actor groups. The interrelating epistemic objects allowed both groups to collaborate with each other across pragmatic boundaries (Carlile, 2002), since both shared "collective obligations towards the lacks displayed by partial objects" (Knorr-Cetina, 1997: 24). This allowed frontline employees to gain sufficient support to conduct 4S activities, or those for performance as well as for learning, from managerial staff. This also facilitated the use of artifacts that played the role of supporting, since managerial staff increased opportunities for frontline employees to revise or

recreate these artifacts (e.g., SOPs or toolboxes) using their ideas. At the same time, this further facilitated the connecting role of artifacts, since both managerial staff and frontline employees had recognized the effects of these artifacts used in their problem analysis activities.

To summarize, the interrelating epistemic objects created a cognitive context for frontline employees to focus on both performance and learning, while also creating a relational context that supported them to conduct activities for performance as well as for learning. At the die-casting plant, frontline employees, with support from managerial staff, continuously improved plant performance through conducting kaizen (see Figure 5–7). This means that the organizational contexts led to frontline employees' persistent acceptance of the learning–performance paradox. This situation strengthened the presence of the learning–performance paradox, which further facilitated the transformation project.

DISCUSSION AND CONCLUSIONS

This paper aims to answer the question: How do material artifacts contribute to transforming organizations in ways that effectively manage the learning–performance paradox? To achieve this aim, I analyzed two transformation projects aimed at implementing kaizen in a Chinese manufacturing plant, and developed a process model that, through the mediation of material artifacts, depicts frontline employees' defensive or proactive responses to the paradox. My emergent theory has theoretical implications for the paradox and epistemic objects literatures, as well as implications for practitioners, which will be summarized in the following sections.

Theoretical Implications

First, this study shows that actors use material artifacts that play multiple roles, the interplay of which enables or constrains the effective management of paradoxes. Paradox studies have begun to acknowledge the critical role material artifacts play in managing paradoxes (Lê & Bednarek, 2017). However, past studies have focused on a particular role of artifacts in managing paradoxes, rather than on multiple roles that contribute to the management of paradoxes in different ways. For example, Knight and Paroutis (2017) showed that artifacts act as sensemaking cues for actors in ways that direct their attention to contradictory issues simultaneously—the role of rendering paradoxes salient. Michaud (2014) further showed how artifacts allow actors to embrace the control–collaboration paradox—the role of enabling actors' acceptance of paradoxes. My study, in line with past studies, shows that artifacts play a particular role in managing paradoxes—for example, triggering social interaction for rendering paradox salient. However, my study further shows that such artifacts interact with other artifacts that play different roles, such as supporting, connecting, and disconnecting, which leads to actors' proactive or defensive responses to the paradoxes. This study therefore extends our understanding of material artifacts used in the management of paradoxes, and highlights the importance of paying attention to the interplay of artifacts that play multiple roles.

This also highlights the limited effects of artifacts that play the role of triggering, or those that act as visual representations. Past lean studies have shown how visual representations, such as kanban cards and andon boards, make problematic situations noticeable, which triggers improvement activities (Adler, 1993; Brunner et al., 2010; Spear & Bowen, 1999). Some researchers who have focused on the use of PowerPoint in strategy making have also shown that PowerPoint slides act as visual representations, which trigger social interaction in ways that direct actors' attention to certain issues or goals (Kaplan, 2011; Knight, Paroutis, & Heracleous, 2018). My study also shows that artifacts act as visual representations, which trigger social interaction in ways that render paradoxes salient. However, it further highlights how difficult it is to sustain the effects of visual representations when such artifacts interact with other artifacts that play the role of disconnecting, and then the situation of competing epistemic objects is created. Here, it should be noted that this study suggests neither that customer-given KPIs and rating scores always play the role of disconnecting, nor that these artifacts always hamper kaizen implementation. It rather suggests the importance of recognizing the double-edged aspect of visual representations: artifacts visually representing the importance of a certain perspective have the potential to compete with other artifacts visually representing a different perspective. The M&A case illustrates how such a competing situation, or competing epistemic objects, creates organizational contexts that lead to actors' defensive responses to paradox. Therefore, researchers who focus on visual representations should expand their horizon to include the interplay of artifacts that play different roles, and carefully observe whether artifacts used for visual representations constitute competing epistemic objects.

Second, this study shows that the interplay of material artifacts mediates knowledge and understanding in different ways, which leads to actors' proactive or defensive responses to paradoxes. This means that artifacts used for managing paradoxes can be interpreted by different actors in different ways. Therefore, managers should recognize that the use of material artifacts for managing paradoxes can lead to multiple, or even undesired, consequences. For example, painted lines and labels that highlighted 4S rules and standards were interpreted as a means for supporting frontline employees' kaizen activities (both performance and learning) by die-casting plant managers. However, the same artifacts were interpreted as a means of disciplinary control (only performance, not learning) by M&A plant managers. In my process model, competing or interrelating epistemic objects induced different actors to develop different understandings of these artifacts, and then different understandings of the learning–performance paradox.

Paradox scholars who have focused on discourse have also highlighted that paradoxes can be understood or constructed differently depending on the situation, putting emphasis on "processual dynamics that depict paradox as consistently emerging, morphing, and changing" (Smith et al., 2017: 5). For example, Sheep et al. (2017) illustrated that actors discursively construct multiple paradoxical tensions, which mutually amplify or attenuate each other and result in actors' negative or positive responses. While discourse-based paradox studies have richly described how discursive interactions shape paradox, as well as conditions for shifting actors' responses to it (Jarzabkowski & Lê, 2017), overemphasizing discursive construction makes it difficult for researchers to capture the persistent aspect of paradox (Smith et al., 2017). My study, unlike discourse-based studies, focuses on conditions for a durable process of reinforcing actors' responses to paradox. In particular, the Die-Casting case illustrates how the learning–performance paradox constructed through micro interactions is mediated by the interplay of material artifacts so that frontline employees continuously accept the paradox. My study therefore highlights the durable aspect of material artifacts (Pratt & Rafaeli, 2006; Stigliani & Ravasi, 2012), which allows actors' specific attitudes or activities to become established in the organization.

My study also shows, in a novel way, how micro interactions are consequential for organizational conditions at a wider level (Lê & Bednarek, 2017). Regarding this, paradox studies have shown that micro interactions or discourses can become the basis for organizational-level conditions when they are seen as legitimate by internal actors (Jarzabkowski & Lê, 2017) or key stakeholders (Abdallah, Denis, & Langley, 2011). Abdallah et al. (2011) further argued that the credibility of a discourse is enhanced when it is embedded in extant institutional ideas. As with Abdallah et al. (2011), my study takes into account the influence of key stakeholders (i.e., the main customer) or extant institutional ideas (i.e., the old 5S project). However, it further shows that this influence can be mediated by competing or interrelating epistemic objects (see Figure 1). In the Die-Casting case, interrelating epistemic objects allowed managers to link frontline employees' learning–performance paradox to their organizational objectives, which created a supportive context for frontline employees to address this paradox, while weakening the influence of the old project promoted by the main customer. My study therefore illustrates how competing or interrelating epistemic objects mediate between micro-level interactions that construct paradoxes and macro-level conditions that shape actors' responses to paradoxes. By doing so, it answers Schad et al.'s (2016: 42) question related to social aggregation: "How do individual approaches to paradox aggregate to higher-level organizational responses?"

Competing or interrelating epistemic objects mediate not only social aggregation but also knowledge and understanding, as mentioned above. On that point, my study supports Knight and Paroutis's (2017) study of "interpretative contexts." They recognized that artifacts can constitute interpretative contexts, which allow actors to become aware of the contradiction and interdependence between alternate poles in a sustainable manner. However, their study linked interpretative contexts only to the emergence process of paradoxes, not to the process of shaping actors' responses. My model, in line with Smith and Lewis (2011), includes both processes, and particularly illustrates how material artifacts contribute to these processes in different ways. For example, the triggering role of artifacts contributes to rendering paradoxes salient, while the interplay of artifacts that play multiple roles creates enabling or constraining contexts for the persistence of the paradoxes among actors. My study, therefore, extends Knight and Paroutis's (2017) research, and explores the roles of material artifacts that contribute to the synchronic (social construction) as well as diachronic (crating contexts for persistence) processes, respectively, of managing paradoxes.

Third, this study shows that actors use material artifacts in ways that create cognitive, as well as relational, contexts for organizational transformation.

Past studies on epistemic objects have illustrated how artifacts mediate actors' cognition through instantiating epistemic objects (e.g., Knorr-Cetina, 2001; Werle & Seidl, 2015). At the same time, studies on boundary objects (e.g., Bechky, 2003; Carlile, 2002) have shown how artifacts allow different actors to develop shared understandings. Some researchers have recognized that artifacts that act as epistemic objects can also act as boundary objects (Ewenstein & Whyte, 2009; Nicolini, Mengis, & Swan, 2012), or, further, that epistemic objects become the basis for social integration (Knorr-Cetina, 1997). However, an integrative framework that allows researchers to analyze the process through which artifacts mediate both actors' cognition and social relations is yet to be developed. The competing or interrelating epistemic objects framework allows researchers to analyze how the interplay of artifacts shapes not only dynamic processes of epistemic activities, or knowledge development processes, but also social relations between different actors.

In particular, competing epistemic objects shed light on degenerative social processes led by material objects, which have not yet been sufficiently discussed in studies on epistemic objects or on boundary objects that have mainly focused on collaborative processes (e.g., Bechky, 2003; Knorr-Cetina, 1997; Nicolini et al., 2012). For example, boundary objects studies have shown that conflict between different groups can be generated as a result of practices using material artifacts (e.g., Bechky, 2003; Carlile, 2002). However, such studies have mainly assumed that conflict is caused by inherent cultural differences between different occupational communities, or different functional goals, rather than being generated by material objects in an unfolding manner. Boundary objects, therefore, "mediate knowledge work in particular instances at given boundaries" (Ewenstein & Whyte, 2009: 27). In contrast, the M&A case illustrates how competing epistemic objects take managerial staff and frontline employees in different directions, through representing the incompleteness of the overall epistemic object to these different groups in different ways. Competing epistemic objects, therefore, give different actor groups a realization of boundaries between them in an unfolding manner. To summarize, this study provides a framework of competing or interrelating epistemic objects that sheds light on the dynamic aspect of social relations shaped by the interplay of material artifacts. However, it respectively analyzes competing epistemic objects and interrelating epistemic objects in different processes. In the future, researchers should analyze further complicated interplay between competing epistemic objects and interrelating epistemic objects in the same process, such as how the situation of competing epistemic objects can be turned into that of interrelating epistemic objects, or vice versa.

Implications for Practitioners

This study has further implications for practitioners, particularly those who attempt to promote incremental innovation, or kaizen. First, this study suggests that practitioners should recognize the limitations of management practices that overemphasize lean or JIT tools. This is applied to the use of artifacts or visual representations that make problematic situations noticeable, such as kanban cards and andon boards (e.g., Adler, 1993; Imai, 1997; Spear & Bowen, 1999). As this study illustrates, the use of such artifacts can lead to organizational contexts that not only enable but also constrain sustainable kaizen implementation. Past studies have stressed that frontline employees play a key role in kaizen (Adler, 1993; Ohno, 1988a). Thus, situations can easily arise in which these artifacts are used for stimulating frontline employees to engage in kaizen, while management concentrates on customer needs and company profits. My study strongly questions the thoughtless use of lean or JIT tools and artifacts that lead to competing epistemic objects, which damage the interrelationship between managers and frontline employees and demotivate frontline employees.

My study also highlights a concern regarding managers who overemphasize visually clean plant conditions, and employees' disciplined behavior to maintain such conditions in 5S. As both cases of my study show, such conditions cannot be automatically linked to kaizen or JIT–TPS implementation, even though lean textbooks have emphasized this link (Imai, 1997; Ohno, 1988b). My findings show that interrelating epistemic objects allow frontline employees to link their 4S or 5S activities to kaizen or JIT–TPS implementation. My study thus recommends that managers pay careful attention to the interplay of different artifacts, which artifacts play the role of connecting or disconnecting in particular, and how the interplay creates enabling or constraining contexts for the sustainable implementation of kaizen or JIT–TPS.

This study also highlights the importance of social or discursive interactions that allow frontline employees to pay attention to performance as well as learning. Considering a general tendency for organizations to seek efficiency at the frontline level (Thompson, 1967), it is highly likely that material

artifacts visually represent problematic situations so that frontline employees pay attention to fixing problems for improving performance in the short term. However, such a focus on performance cannot be automatically linked to their focus on learning. This study illustrates how TPS-C skillfully guided conversations so that actors paid attention to performance as well as learning. This study thus informs practitioners about the importance of developing communication or facilitating skills (Luscher & Lewis, 2008; Sheep et al., 2017), which discursively connect performance issues to learning issues. Such skills could be linked to the use of rhetoric (Bednarek et al., 2017; Jarzabkowski & Sillince, 2007) or humor (Jarzabkowski & Lê, 2017), which should further be explored in association with the use of visual representation artifacts, or lean or JIT tools, in the future.

Another implication of this study is that practitioners should rethink the role of lean or kaizen consultants. Over the past decade or so, many companies have used such consultants for implementing kaizen or incremental innovation, probably due to the impact of such seminal books as those by Imai (1986), Shingo (2007), and Womack and Jones (1996). It is expected for practitioners who pay expensive fees to consultants to request them to solve problems to improve company performance as soon as possible. However, as my findings suggest, situations in which consultants solve problems by themselves, or just give instructions on how employees should solve problems, will deprive frontline employees of opportunities to find reasons underlying these problems and to explore ideas for improvement by themselves. Such a situation makes it difficult for frontline employees to sustain the learning–performance paradox. Practitioners should keep in mind the limitation of taking a short-term view to solve problems by using external consultants, or even internal managers and engineers, that could deprive frontline employees of opportunities for exploring ideas for future kaizen.

Limitations and Future Challenges

My analysis of the two transformation projects in a Chinese manufacturing company provides a process model that shows contrasting cases. This model illustrates how different approaches to the use of material artifacts lead to competing or interrelating epistemic objects, which create enabling or constraining organizational contexts for frontline employees' persistent acceptance of the learning–performance paradox. The research setting, however, defines the boundary conditions and limitations of my theory, which should be addressed in future.

In my theory, competing or interrelating epistemic objects play a central role in leading to frontline employees' responses to the paradox. This relationship is likely to be salient and relevant for organizations with a formal, hierarchical structure, such as a mechanistic form (Burns & Stalker, 1961) or a bureaucratic form (Adler, 1993). However, in organizations with an inherently organic form (Burns & Stalker, 1961), such as knowledge-intensive companies, frontline employees have more authority and independence, and are less affected by managers who provide them with support for conducting innovative activities, or addressing the learning–performance paradox. Therefore, the relevance of my theory may depend on the extent to which the organizations are hierarchically structured.

This suggests that the insights of my theory can be transferable to service industries that have actively introduced lean tools and artifacts (McCann, Hassard, Granter, & Hyde, 2015; Staats, Brunner, & Upton, 2011). In large service companies, such as logistic service companies and general merchandise stores, or even general hospitals with a bureaucratic organizational form, frontline employees might have little authority and independence. In such a situation they are likely to respond to the learning–performance paradox defensively when competing epistemic objects deprive them of management support and understanding. In the future, researchers should consider different industrial settings, and test whether the insights of this study can be applicable beyond the setting of manufacturing industries.

The research should also be extended to include cases from countries other than China, particularly Western countries where actors are likely to adopt tradeoff (either–or) approaches, rather than embrace paradoxical thinking (Eisenhardt & Westcott, 1988; Keller et al., 2017). In Western countries, managers may face a greater political struggle in using frontline employees as a driving force for incremental innovation than in Asian countries. For example, past studies have illustrated how managing resistance from labor unions in countries such as the United States and Sweden play a crucial role in implementing incremental innovation (e.g., Adler & Cole, 1993; Fucini & Fucini, 1990). In the future, researchers should consider different political settings, including the effects of labor unions, and examine how power politics or conflict affect the management of paradox. It would be interesting to analyze how, or in

what context, conflict between different actors caused by competing epistemic objects can be a generative force, for example acting as a source of innovation, as suggested by Hargrave and Van de Ven (2017).

Finally, my theory presupposes a situation in which organizations that face the need for implementing incremental innovation or kaizen attempt to manage the learning–performance paradox. This setting is suitable for analyzing an emerging process of paradoxes, as well as the resulting actors' proactive or defensive responses to the paradoxes. In future, however, researchers should also focus on exploring a process that shifts from actors' proactive to defensive responses, and vice versa. It would not be easy to move from a reinforced defensive response that is underpinned by competing epistemic objects to a proactive response. In order to conduct such research, we should develop a more elaborate framework to analyze complex interplay between social interaction or discourse and materiality.

Researchers should also focus further on how organizations that have already established kaizen practices, like Toyota, maintain the learning–performance paradox through ordinary business activities. Among the most important aspects is how organizations maintain this paradox for incremental innovation in a situation where there is a need for radical, product innovation—for example, current automotive companies that face ever-increasing complexity in customer needs and technological changes (Aoki & Staeblein, 2018; Aoki & Wilhelm, 2017). In such a situation, organizations need to manage more complex, interconnected paradoxes, including learning–performance, exploitation–exploration, and incremental–radical innovations. This would amplify competing and conflictual situations and political struggles, such as between development and production divisions, or between divisions for new and existing products. Researchers should consider the complex interplay between such multiple paradoxes (Andriopoulos & Lewis, 2009; Sheep et al., 2017), which will dynamically evolve over time (Jarzabkowski et al., 2013a).

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