Offshoring Digital Work, But Not Physical Output: Differential Access to Task Objects and Coordination in Globally Distributed Automotive Engineering and Graphic Design Work

Samantha R. Meyer
Northwestern University
srmeyer@u.northwestern.edu

Casey S. Pierce
Northwestern University
cspierce@northwestern.edu

Yubo Kou
U of California, Irvine
yubok@uci.edu

Paul M. Leonardi
U of California, Santa Barbara
leonardi@tmp.ucsb.edu

Bonnie A. Nardi
U of California, Irvine
nardi@ics.uci.edu

Diane E. Bailey
U of Texas, Austin
debailey@ischool.utexas.edu

Abstract

When scholars and practitioners consider the implications of offshoring work, their primary concern is often the impact offshoring has on communication between people at different sites. When time zones and geographic boundaries separate employees, communication is limited, making it difficult for remote colleagues to form trusting and familiar relationships with one another. However, offshoring not only obstructs person-to-person interactions, it also impedes person-to-object interactions. This is potentially problematic as many organizations today still produce physical products, such as printed marketing collaterals, computers, home décor, or automobiles. Though organizations that create physical outputs may engage in digital work processes, people at these organizations may still rely on interactions with the physical objects that they produce in order to complete tasks. In this paper we investigate impeded person-to-object interactions at two offshore work sites representing two different occupations: automotive engineering and graphic design.

1. Introduction

As modern organizations increasingly digitize their work processes, more workers spend their days interacting with technologies such as enterprise social media [1], collaborative technologies for software development or knowledge sharing [2], and even virtual simulations [3], [4]. The digitization of work has led many firms to consider whether they should offshore their digital work tasks to lower-cost employees. The allure of substantial cost benefits in hiring offshore workers in developing nations has prompted many organizations to offshore digital, white-collar work to a well-educated, international workforce [5]–[7]. Many offshore sites complete critical (and digital) tasks for their onshore counterparts, including information technology services, customer support, engineering design work, and even research and development [8]. In addition to the cost-saving benefits, offshore sites can also serve as global innovation hubs [9], [10] and can increase overall productivity with an around-the-clock workforce [11].

Although offshoring digital work can provide organizational benefits, problems may arise when the digital work shipped offshore does not sufficiently capture the physical aspects of the work that exists onshore. When an organization produces a physical output, offshoring digital work may not only separate people from each other, but also separate people from physical objects related to their work. For example, an onshore architect may work predominantly using computer-aided design (CAD) software, with a goal in mind to create a building, landscape, or public space. If the CAD design work is done at an offshore site, the remote worker may not be able to see or feel the materials used, the physical prototypes of the space, or the final product itself. In such cases, where offshore sites are only privy to digital aspects of work, even when these workers are contributing to a physical output, we ask the following question: How and in what ways does the separation of people from physical task objects affect globally distributed work processes? We explore this research question through a study of two offshore firms that have very different digital work processes and very different physical outputs - a graphic design and an automotive engineering firm. To inform our investigation, we briefly summarize findings from literatures on globally distributed work, routine work, and coordination.

2. Globally Distributed Work

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When organizations offshore administrative and technical work, globally distributed employees must work together without the ability to communicate face-to-face, meaning workers must overcome spatial and temporal distances to work together towards a common goal [12], [13]. To overcome these distances, distributed workers use digital communication technologies such as email, phone, or video conferencing to facilitate communication across space and time [3], [14]. The growing importance of communication technologies in distributed work has motivated researchers to focus on the impact of mediated communication on distributed work practices [13], [15], [16].

Although research on the role of digital communication technologies has highlighted that distributed workers can increase an organization's flexibility and responsiveness [15], the inability to engage face-to-face can be problematic. Research has found that when people work far away from one another, they struggle to build sufficiently strong working relationships. Distributed workers struggle to build trust [15], [17]–[19] and can develop conflicts with one another due to incomplete messages or misunderstanding [13], [20], [21]. The logistics of completing distributed work can be an obstacle as well. Herbsleb and Mockus [22] found that globally distributed software development teams took about two and one-half times as long to complete tasks compared to their co-located counterparts. Taken together, this body of research suggests that distributed work can cause problems because the extent to which people are separated from one another impedes their ability to communicate effectively about their work.

3. Coordination in Distributed Work

Although studies show that relationship-development is impeded when workers are far away from each other physically, distributed workers still depend on their colleagues to successfully complete work tasks. Remote and distributed workers are increasingly engaged in innovative and non-routine tasks [23], [24], meaning that offshore and onshore sites are not operating independently of one another. For these reasons, distributed workers must dedicate considerable time and effort to coordinate with each other [16], [25]. Successful coordination occurs when there is "reciprocal predictability of action" [26, p. 849], meaning that offshore and onshore workers coordinate their work when they engage in consistent and certain exchanges about the task at hand. The importance of coordination for people who engage in interdependent, non-routine distributed work processes has led to a line of research that focuses on how to improve the way people coordinate their work.

Scholars broadly recommend that to improve coordination in distributed work, organizations should create opportunities for distributed workers to engage in ongoing social exchanges to build reciprocal relationships and ultimately, trust [17]. Additionally, scholars propose that organizations should minimize the power disparity between different work sites (particularly, those onshore and offshore) such that employees at all locations feel aligned with a common goal [27]. Furthermore, distributed organizations can facilitate collaboration by ensuring group members have access to sufficient technologies that promote communication or by incentivizing workers to collaborate across boundaries [28].

Overall, scholars seem to favor two approaches to improve coordination in distributed work: reduce interdependence or increase communication [26]. However, because remote and distributed workers may engage in non-routine tasks, reducing interdependence may be difficult. For this reason, increased communication may be critical. That is, when people who must work together are separated by time zones and distance, they must communicate frequently to effectively coordinate their work.

Given the importance of communication for distributed work, it is unsurprising that much of the research on distributed work processes analyzes and compares available communication media [29]–[31]. For example, Cramton [21] studied how technology-mediated teams utilized different digital tools such as email, online chat, or phone to collaborate effectively on a joint project. However, communication tools can also hinder work processes. Majchrzak, Malhotra, and John [35] found that distributed team members encountered difficulty sharing knowledge with one other because the technology, a digital collaborative notebook, was unable to support knowledge exchange.
As these studies emphasize, communication media matters for distributed work because people are separated from one another and if their communication tools are inadequate, coordination and work processes suffer.

However, in globally distributed work groups, people may not only be separated from their colleagues; distributed workers also may be separated from objects important for their work. Offshore workers may be completing tasks relevant to work outputs they never themselves see in person, be it a car, a building, a phone, or even a billboard next to the freeway. Research on co-located work suggests that seeing these physical task objects in person is important. Beckhy's [32] study of occupational communities told of a case where digital models of a turbo pump appeared to be correct to engineers, but the assembly workers who built the machine were able to see problems with the design because they interacted physically with the pump and machine as a whole. When engineers were able to see the physical positioning of the object's components, the physical outputs were able to inform the digital design. Similarly, Ewenstein and Whyte [33] found that team members used architectural drawings and blueprints as frames of reference to jointly design new building models. Without these tangible blueprint objects, they would have had difficulty communicating tacit information, thus hindering their coordination efforts. Of course, even these digital task objects have some degree of physicality and can encode valuable information about the physical task object represented by the digital one [34]. In sum, however, it seems that digital and physical objects provide valuable information about work tasks, and it may be best if all employees have access to both.

Overall, scholars have shown that access to physical task objects matters to co-located workers, and that access to different kinds of communication media matters for distributed work. Yet, scholars have not yet explored the intersection of these ideas, that is, if access to physical task objects matters for distributed work. To explore the larger issue of how the separation of people and objects may affect globally distributed work processes, we aim to answer the question: how does access, or lack of access, to physical task objects influence coordination in distributed work? If in fact access to physical task objects matters for distributed work, it seems that coordination in globally distributed work groups may be a function of the separation of people from other people, as well as a function of whether or not remote workers are separated from the physical objects related to their work.

4. Methods

To answer our research questions, we selected two organizations with offshore locations producing very different types of outputs – analyses of automobile performance and graphic design of marketing materials. Our two study settings were International Automobile Corporation (IAC) and Global Consulting Corporation (GCC), both pseudonyms.

The first research site, IAC, is a large automobile manufacturer headquartered in the United States whose distribution of product development work across several continents is increasingly typical of the industry. Although the majority of IAC's engineering workforce resides in the mid-west, IAC has long maintained engineering operations abroad and today has engineering centers in eight countries. At the end of 2003, IAC opened a captive offshore center in India to provide digital engineering services to its engineering centers around the globe. The engineers in the India center provided their global colleagues with digital, computational models of vehicles as well as results of computer simulations of vehicle performance generated with the models.

The second research site, GCC, is a multinational consulting firm headquartered in France. The consultants across GCC's areas of expertise (e.g., supply chain, technology implementation, and accounting) used a variety of printed and digital materials to communicate information to clients as well as marketing collaterals to promote their services. To help consultants produce professionally designed materials, GCC dedicated an entire marketing services division to graphic design and stationed its largest site in India. Graphic designers in the India office created a range of creative products, including brochures, reports, infographics, videos, and Power Point slide decks.

At IAC, we conducted 42 semi-structured interviews [36] in 2008, which served as the impetus to explore the role of physical task objects more explicitly through follow-up interviews. We conducted 27 follow-up interviews at IAC in 2013 and 28 interviews at GCC in 2012, all of which focused on the role of digital and physical objects in work tasks, and on the extent to which workers coordinated with their peers in India and their onshore colleagues. Interviews lasted from 45 minutes to 1 hour, and all interviews were audio-recorded and transcribed verbatim. All names of interviewees included here are pseudonyms and details have been changed to provide anonymity.

5. Analysis

We took a grounded theory approach [37] to analyze the data. We first read all interview transcripts and used our initial perceptions to generate a starting list of codes [38], which included ideas about digital and physical objects in work processes, as well as the coordination necessary to complete work tasks. From there, we returned to the data to conduct a systematic analysis of the themes that arose, and after several iterations of coding, we identified a central phenomenon in the data – how coordination in offshoring relationships is influenced by separation from task objects. With this theoretical frame in mind, we went back to the data to find episodes [39] where offshore workers described the process involved in conducting a specific work task such as creating a model of vehicle performance in automotive engineering or redesigning a slide deck in graphic design. We coded these episodes along two dimensions: (1) the level of coordination, and (2) the task objects.

To code the level of coordination that occurred in each episode, we followed previous work on helping and information-seeking [26], [40] to create three levels of work coordination. The first level (L1) is *local coordination,* which reflects co-located offshore workers asking questions of each other. The second level (L2) is *global coordination: information seeking or sharing.* This level reflects when offshore workers need to give or seek information from their onshore counterparts. The highest level (L3) of coordination is *global coordination: problem solving,* which highlights when offshore and onshore workers need to engage with one another iteratively to figure out a solution to a problem that arises when completing a work task. For each episode, we identified whether one or more levels of coordination were necessary to complete the given task.

We also coded each episode for task objects. We started by identifying whether the output of the work task was digital or physical in form. The form of the final output is important because task outputs represent the final goal of the interdependent work processes that involved both onshore and offshore workers. Table 1 gives examples of digital and physical task outputs at GCC and IAC.

Table 1. Example of Codes for Task Outputs

	Digital Output	Physical Output
GCC	A graphic design output that was digital in form. (e.g. PowerPoint slide deck)	A graphic design output that was physical in form. (e.g printed brochure, folded and on appropriate paper type).
IAC	An automotive design output that was digital in form. (e.g. Computer code to extract and analyze data from simulations)	An automotive design output that was physical in form. (e.g. Car component or entire vehicle)

Though the digital or physical forms of the final task output drove our analysis, we fully recognized that onshore and offshore workers often interact with many different kinds of task objects as they complete work tasks. Workers we interviewed utilized and referred to objects such as books, pen and paper, PDF files, CAD files, complex simulation software, prototypes, and many others that played a role in how they completed work tasks. The digital and physical objects offshore employees used were useful to gather valuable information about the task at hand, and workers iterated between these different objects in different ways. Although the extent to which these objects closely represent the final output of the work task differ, we coded all these objects as task inputs because they facilitated the production of the final output. Table 2 gives examples of digital and physical objects used as inputs in work processes. We used these codes as a way to better understand why coordination was necessary as offshore and onshore workers sought to produce a physical or digital output.

Table 2. Example of Codes for Task Inputs

	Digital Inputs	Physical Inputs
GCC	A graphic design sample, draft, or template that was digital in form. (e.g PowerPoint template, PDFs or Illustrator files)	A graphic design sample, draft, or template that was digital in form. (e.g Previous versions of printed posters)
IAC	An automotive design prototype, model, or test result that was digital in form. (e.g Computer codes for optimizing physical models, Virtual simulations or CAD models)	An automotive design prototype, model, or test result that was physical in form. (e.g. Auto parts from a model car, Prototype of a final chassis design)

As we began our analysis of how access to task objects impacted coordination, we found that the routine nature of the work task negotiated the relationship between the task object and coordination. Episodes in our data captured how offshore workers engaged in both routine and non-routine tasks, and that the extent to which access to physical task objects mattered depended on the routineness of the task. For this reason, we also coded each episode by whether it involved routine or non-routine work. Workers indicated routine work through explanations that they do tasks like this frequently, and indicated non-routine work when they explained they were initially unfamiliar with how to start the task or unsure what steps the task involved.

6. Findings

We present our findings in four sections based on the defining attributes of each episode that necessitated a certain level of coordination: routine digital outputs, routine physical outputs, non-routine digital outputs, and non-routine physical outputs. Table 3 summarizes our findings, with checkmarks indicating which level of coordination was required for each combination of routineness of work and task output across the two sites in our study. The striking feature of Table 3 is the identical cascading pattern of coordination levels at each site as work routineness moves from routine to non-routine and the task output moves from digital to physical. This pattern indicates that highest levels of coordination occurred when work was non-routine and the output was physical. In the sections that follow, we provide examples of episodes that illustrate the levels of coordination needed for each combination of routineness and task output.

Table 3. Coordination by Routineness of Work and Task Output

Site	Routineness of Work	Task Output	Coordination		
			L1	L2	L3
GCC	Routine	Digital	✓		
		Physical	✓		
	Non-routine	Digital	✓	✓	
		Physical	✓	✓	✓
IAC	Routine	Digital	✓		
		Physical	✓		
	Non-routine	Digital	✓	✓	
		Physical	✓	✓	✓

6.1. Routine Digital Output

Both automotive engineers and graphic designers coordinated their work only at the local level (L1) for routine tasks that produced a digital output.

An episode from IAC revealed that automotive engineers in India were once struggling to validate data and simulation requests from onshore sites because each engineer chose his or her own slightly different set of model specifications to run tests. As Sameer, a CAE engineer, explained: "*[E]verybody is building on their own with different tools...And they have different element size...there is no commonality…we are spending three times of the effort.*" In other words, though these data analysis tasks were routine and not complicated to complete, when each engineer chose a slightly different set of test parameters, the test results could not be compared. The Indian engineers thus worked together locally to develop a standardized list of measurements to ensure all simulation models were uniform and could be compared.

Graphic designers at GCC tell a similar story. For example, a document specialist in one episode was assigned the routine task of modifying a Power Point deck, and wanted to better meet the requirements without losing some of the visual appeal. He sought out his colleague in India and asked for some design advice. As he described, *"[O]ne suggestion that one colleague told me is like just paste the text underneath draw a line, just a line and then draw another line to point out to where it is pointing…So, that it doesn't look awkward, it looks very much neat and simple."* In both sites, offshore workers only needed to coordinate with each other locally to verify that the routine digital output they were working towards was correctly and accurately produced.

6.2. Routine Physical Output

As Table 3 shows, routine tasks that produced a physical output required automotive engineers and graphic designers to coordinate their work only at a local level (L1), just as with routine digital output.

In an episode from IAC, an automotive engineer in India needed to analyze a digital model of car components, which would inform the design of the physical car parts. This kind of analysis work was common for the offshore engineers, who were often sent digital files to run tests on; in fact, the protocol for these analyses was codified in an online document that showed the entire procedure. Yet, the engineers sometimes found the explicit instructions in the document to be incomplete. For example, Vikram, a CAE engineer, explained how he wanted to verify the geometry of the analysis before beginning the tests: "*If there is any sentence [in the document] like, 'First of all you need to make geometry cleanup,' [that] means I will ask my team mates how to make the geometry cleanup. ... What all the features which we don't want, which we don't consider....*" Since Vikram did not know what features to consider when verifying his analysis against the physical car itself (which was in the US), he turned to his colleagues, who knew the answer because the task was common and routine.

In a similar example of routine work involving physical outputs from GCC, a graphic designer in India wanted to make modifications to improve an 80-page report she was working on for her onshore colleagues, but was unsure if other designers would agree that her modifications improved the quality and readability of the document, which would be printed and bound onshore. She visited her local colleagues at their desks to show them her designs and ask for feedback. As Priya explained: "*[I]f I am stuck there, I talk to them and [say,] 'Can you see whether it's looking good or not, do you want to read this page?'…*" Even though Priya knew the routine process of creating the report, she needed her local colleagues to verify her designs were acceptable and good choices.

Overall, we found that routine tasks only necessitated local coordination, even when the output was physical and offshore workers were detached from physical outputs.

6.3. Non-Routine Digital Output

Though local coordination was sufficient for offshore workers to verify and complete routine tasks, regardless of whether the output was digital or physical, non-routine tasks posed more significant barriers. For non-routine tasks that produced a digital output, coordination was needed at the local as well as the global level.

At IAC, an automotive engineer needed to extract data for a post-processing analysis, but the data was in an incompatible form with which the Indian automotive engineer was unfamiliar. As Tushaar, a senior engineer, explained: *"[W]e had to have some scripts to post process and the results automatically…put it in a tabular form. The thing is these were written and, written for XP…and we can run only…UNIX…we need to be able to post process the results, look at the results, and also see where we are going."* Tushaar went on to explain how he worked with other local engineers to run the scripts, but no one locally was familiar with this kind of problem. He thus reached out to the European engineers, who then sent a document to India that instructed the engineers on how to quickly and effectively conduct the post-processing. In this way, seeking more information from the onshore site indicated a higher level of coordination (L2) was needed for the offshore engineer to successfully complete this non-routine digital task.

At GCC, graphic designers who completed non-routine tasks that produced a digital work output also needed to coordinate both locally and globally. For example, one episode captured a time when a web designer in India was asked by an onshore client to create a new web page for the knowledge-sharing site used internally at the organization. However, the client made requests that did not follow the standard guidelines for web page design. As a result, the Indian designer needed to tell the onshore client what could and could not be done. As Ajay, the Indian web master, explained: "*I have to educate [the client]. I have to share some of the slides, our guidelines precisely about the pixels I mean the sizes this much, the height can be this much, the width can be this much only."* Once this additional information was conveyed, the web page could be accurately designed and published to the server. At both sites, non-routine tasks that produced a digital output necessitated one additional level of coordination – global information seeking or sharing – to complete work tasks.

6.4. Non-Routine Physical Output

Our analysis so far has shown that routine work tasks needed only local coordination, regardless of whether they produced a physical or digital output. This finding suggests that when workers are separated from physical objects related to their work, they can still accomplish routine work tasks because they have the infrastructure in place locally to verify these tasks. Though whether the output is digital or physical does not generate any differences in the level of coordination for routine tasks, we find that this difference does matter for non-routine work. Though non-routine tasks that generated a digital output required two levels of coordination, both engineers and graphic designers required all three levels of coordination (L1, L2, and L3) to complete non-routine tasks that produced a physical output.

One episode from IAC exemplified how automotive engineers needed to collaborate considerably with both local and remote colleagues when working to build a computer model of a new car prototype used in a wind tunnel test. Rahul, a senior engineer, explained how he worked with his colleagues repeatedly to ensure the model was accurate, *" We will be doing lot of analysis and lot of interaction will happen, because it has to represent exactly…the reduced-scale model they are testing…It includes even a tape; putting the tape, sponge, everything they [the US engineers] check…."* Rahul went on to explain how the Indian engineers built a replication of the prototype on-site, and some even went to the US to see the prototype in person: *"We will have more interaction[s] and…we build it here, the model, exact replication of the model… when I was in U.S.…someone will take me to the wind tunnel testing… to have some idea of what they are testing."* This episode exemplifies when offshore engineers needed to complete a non-routine task that produced a physical output, they needed to collaborate in a problem-solving manner with the onshore engineers to verify that the computer model built offshore captured the physical output onshore.

Though it would seem that car designs are far more complex than marketing material or other graphic design outputs, and thus would require more coordination, we found that graphic designers in India also needed to extensively coordinate both locally and globally to produce a non-routine physical output. In one episode from GCC, an experienced graphic designer, Shreya, described a time when she needed to create a special advertising card, which she had never done before. This particular type of collateral was complicated to design because it was a foldable marketing piece, so the design required a 3D visualization to illustrate how the collateral looked as it was folded and unfolded. When the Indian graphic designer completed the PDF of the card design, she sent it to her client onshore, which led to a back-and-forth exchange to verify the design was correct. As Shreya explained, *"[T]he client is saying, 'Okay, no, this would be not here and there is like a conflict.' I am saying, 'No, if you want this, that cohort page should be here.' And after some I explained him entirely…I shared [my] screen and explained that, 'Okay that is the thing.' And then [he was] convinced and we are okay, and now let's go with it."* This episode captures how non-routine graphic design work that produced a physical output also necessitated global problem-solving efforts because offshore workers like Shreya were unable to verify their digital work by looking at the physical version of it. As a result, offshore workers needed to coordinate with onshore workers to verify their work.

7. Discussion & Conclusion

Our findings suggest that when people are separated from objects that are important for non-routine work tasks, they must increase the degree to which they coordinate with others. As Table 3 reflects, only local coordination (L1) was needed in cases of routine tasks independent of whether the output was digital or physical, or the type of work (graphic design or auto engineering). Global coordination in the form of information sharing and seeking (L2) or problem-solving (L3) arose when tasks were non-routine. In this way, the routineness of distributed work interacts, so to speak, with the work output. Though one may expect that access to physical task objects matters uniformly, our findings indicate it matters, but only when the work task is non-routine.

We theorize that the interaction between task objects and routine tasks occurs because onshore and offshore workers had different levels of access to the physical outputs they were trying to produce, as well as the physical inputs they needed to inform and verify their work processes. Therefore, when non-routine work tasks were given to offshore workers, the inability to interact with physical task objects was problematic. As Table 4 shows, when work tasks were non-routine, offshore workers depended on onshore workers to verify their work because offshore workers did not have access to or the ability to see physical objects relevant to the task, such as prototypes or draft boards. When work tasks were producing a routine physical output, offshore workers also did not have access to physical objects, but coordination needs were low because local coordination was sufficient to address ambiguity or uncertainty in work tasks. Offshore workers could simply refer to established procedures or to their local colleagues to get their questions answered. Our finding that access to relevant physical objects can influence coordination has implications for theories of distributed work, and for scholars who study the role of objects in work processes.

Table 4. Coordination by Routineness of Work and Task Objects for both IAC and GCC

	Task Objects			Coordination		
	Output Object	Onshore Inputs	Offshore Inputs	L1	L2	L3
Routine	Digital	Digital	Digital	✓		
Routine	Physical	Digital, Physical	Digital	✓		
Non-routine	Digital	Digital	Digital	✓	✓	
Non-routine	Physical	Digital, Physical	Digital	✓	✓	✓

Scholars of distributed work have extensively explored how and in what ways different communication media impact communication between workers separated by physical distance and across many time zones [42]–[44]. This literature speaks to the importance of communication for coordination in distributed work, but our findings exemplify that the extent to which coordination is needed may also depend on access to physical task objects. Our findings coupled with existing literature on distributed work emphasize that both communication media and access to task objects impact coordination. Future research on distributed work may benefit from investigating communication media and task objects together in distributed contexts, and exploring the possible interplay between them.

More specifically, our findings highlight that scholars of distributed work must recognize the importance of physical objects in work tasks, particularly as distributed workers engage more often in non-routine tasks. Past studies have found that physical objects are important learning tools and can be essential for people who want to verify work tasks [45], and digital representations of physical objects, no matter how good those representations may be, are not equal to the physical objects they embody [32]. Although digital representations can contain extremely detailed bits of information, they still cannot replicate the same type of information embedded within physical objects [46]. This line of research, then, seems to suggest that the physicality of particular objects can offer cues and clues about work processes that immaterial objects are unable to signal to workers because of their different material form. Our findings provide support for this proposition. Offshore workers in our study often struggled to use only digital representations to make sense of physical objects, such as CAD files to understand a car design. Physical objects were needed for learning and information sharing, particularly in non-routine tasks. And without physical objects, the graphic designers and auto engineers in our study had to coordinate extensively with their peers onshore.

In addition to the importance of physical objects for verification and individual understanding, scholars suggest that access to physical objects matters because access to digital or physical task objects can influence the ways in which people interpret tasks [47]. Scholars that study artifacts and the coordination around artifacts emphasize how physical objects can help workers unify divergent ideas around a task [4], [32], [48]. In this way, physical objects can improve coordination because they help generate agreement and wider understanding. Though these studies have shown that physical objects may solve coordination issues locally because all workers can engage and interact with physical objects, our findings indicate that physical objects may spawn coordination issues globally if workers in different locations have different levels of access to those physical objects. In our study, it may not be just that offshore workers did not have access to the physical artifacts of their work that increased coordination; rather, coordination increased possibly because offshore workers did not have access to physical objects while onshore workers did, making it hard for these two groups to come to consensus and agreement about work tasks. Scholars of coordination may want to further explore how coordination issues derive from both lack of access and from unequal access to physical objects in distributed work.

Our findings also have important practical implications for organizations that offshore administrative or technical work. Based on our findings, it would seem that when distributed workers complete non-routine tasks, organizations may want to (1) provide physical objects to workers at their work site, (e.g., creating a car crash facility or tear down room for automotive engineers in India) (2) physically move individuals to the work site that has these physical task objects available, or (3) create a supportive infrastructure that helps people verify work tasks with one another across borders when physical objects are not present. Importantly, our findings suggest that these strategies are relevant across a spectrum of global work processes. To build a virtual car model, engineers at IAC needed to see the car itself to understand how the parts felt, behaved, and even sounded. Offshore engineers needed access to physical objects related to their work, and the same is true for offshore graphic designers. At GCC, even having access to printers that could be adjusted to their onshore clients' standard size paper would have helped them print interim design versions that replicated what their clients would see. Therefore, organizations that offshore work could reduce global coordination needs by providing direct access to physical task objects because access to these objects can reduce the need for offshore workers to consult with onshore workers to verify work tasks and can reduce misunderstandings about the task between workers onshore and offshore. Lastly, organizations could create a supportive infrastructure that facilitates coordination when there is differential access to task objects, such as by creating organizational structures that routinize work tasks.

However, costs are involved with each of these three options. Often times physical objects and people cannot easily be moved across international sites, meaning that providing equal access to task objects in globally distributed work may be financially prohibitive. And routinizing work tasks may stifle creativity and efficiency, or undermine the benefits of instituting offshore sites that operate as sources of innovation. In sum, our findings suggest that access to physical task objects matters for non-routine work; however, in reality, organizations must consider the costs involved with routinizing work or providing access to physical objects, and strategize about how much access to afford and to whom to afford that access in order to improve coordination.

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