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Learning to demo: the sociomateriality of newcomer participation in engineering research practices

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An understanding of newcomer participation is important both from the perspective of engineering organizations and to prepare future engineers but we know little about how newcomers to engineering practices traverse their trajectory of participation. Prior work on newcomers has addressed socialization processes but has overlooked the sociomaterial nature of engineering practices and its consequences for newcomer participation. In this paper, I present an in-depth case study of a newcomer navigating his early days in an industrial research and development laboratory. I identify 'demoing', or the use of prototypes to communicate research outcomes, as a highly valued practice at the studied firm and trace a newcomer's participation from entry until his first demo, which signaled significant progress toward full participation. I argue that as engineers move from being novices toward fuller participation, they need to become sociomaterial experts – *both* socially adept and proficient at using materiality in conjunction with each other.

Keywords: newcomer participation; engineering research; sociomateriality; qualitative case study; prototypes; demo; learning; communities of practice

Introduction

Newcomer participation is fundamental to organizational success since integration of newcomers determines future performance, productivity, and innovation. Therefore, most institutions attempt to carefully integrate newcomers and thereby reduce turnover, avoid identity incongruence between the worker and the firm, and consequently, increase worker motivation. According to empirical studies of newcomer integration into organizations, newcomers proactively seek information and their information acquisition determines their social relationships and consequent assimilation in the work environment.[1] Newcomers essentially use information they acquire to make sense of their new world and usually look for what, how, and whom kinds of information which they acquire by observing, monitoring, or asking others.[2] Within the context of engineering, Korte[3] uses the

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[1]Ostroff and Kozlowski, "Organizational Socialization as a Learning Process" Van Maanen and Schein, "Toward a Theory of Organizational Socialization"; Miller and Jablin, "Information Seeking During Organizational Entry".

[2]Louis, "Surprise and Sensemaking"; Morrison, "Newcomer Information Seeking".

[3]Korte, "How Newcomers Learn the Social Norms of an Organization".

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socialization perspective and through an interview study of new engineers shows that work group socialization norms were significant in how newcomers integrated and perceived their job. Using a social exchange lens, he reports that the primary driver of socialization was relationship building and the primary context for socialization was the immediate work group. The findings from the study highlight the relational aspect of newcomer integration whereby both newcomers and those in the organization share the responsibility.[4]

Studies emphasizing organizational socialization and assimilation, which dominate newcomer literature, provide strong evidence for focusing on the relational aspects of newcomer entry but fail to shed light on the relationship between the actual work undertaken by newcomers and their integration. They fail to provide details of what newcomers *do* as they socialize and what this participation means to them; a perspective that is fundamental to an interpretive understanding of newcomer participation in a profession, such as engineering where technical competence is highly valued.[5] As a consequence, it is hard to understand what is unique about engineering and newcomer participation.

A practice-based approach to newcomer participation

In recent years, another stream of research that argues for a practice-based understanding of newcomers has emerged.[6] Presented under analytical frameworks, such as cognitive apprenticeship,[7] situated learning,[8] and community of practice,[9] this work essentially argues that newcomer participation is a guided process that occurs as experts and novices interact within a specific social and material environment. As newcomers participate in a practice, they move from a position of peripheral participation to full participation and the fundamental change that occurs – or learning that happens – is a transformation in their identity.[10] A change in identity – where newcomers perceive themselves as full members as opposed to peripheral participants – signifies that they have learned to participate in the practices of the community they have entered. These situated accounts of newcomer participation move beyond mere socialization arguments toward an emphasis on development of expertise and change in identity, accordingly, they argue that newcomers not only need to socialize but have to become a *participating* member of a community.

In the present study, I appropriate the participatory metaphor as an analytical lens to examine newcomer trajectory.[11] This in-depth descriptive and interpretive

[4]There is a dearth of literature on socialization of engineers in work practices. Studies that document socialization of engineering students in engineering education, such as Dryburgh, ''Work Hard, Play Hard'', or into professional practice through curriculum, such as Dannels, ''Learning to Be Professional'', are more common.
[5]Kunda, *Engineering Culture*.
[6]Brown, Collins, and Duguid, ''Situated Cognition and the Culture of Learning''; Lave and Wenger, *Situated Learning*; Wenger, *Communities of Practice*.
[7]Brown, Collins, and Duguid, ''Situated Cognition and the Culture of Learning''.
[8]Lave and Wenger, *Situated Learning*.
[9]Wenger, *Communities of Practice*.
[10]Brown and Duguid, ''Organizational Learning and Communities-of-Practice''; Lave and Wenger, *Situated learning*; Wenger, *Communities of Practice*.
[11]Although I do not elaborate on the identity perspective, given the focus of this particular paper, the study presented here also adds to the literature on situated learning and the idea of ''legitimate peripheral participation'' by actually examining newcomer participation

examination allows me to closely study the relationship between the social and the material, important aspects of newcomer participation that have not been investigated as an integrated aspect of participation. According to Orlikowski and Scott,[12] the sociomaterial view is central in understanding human practices since the social and the material are constitutively entangled in everyday life.[13] This position of 'constitutive entanglement' does not privilege either humans or technology but instead argues that the social and the material are inextricably related – there is no social that is not also material, and no material that is not also social.[14] Therefore, to understand newcomer participation, particularly in the context of engineering practices, it is crucial to adopt a sociomaterial lens in order to examine the sociomaterial assemblages of newcomer participation. Given the materiality of engineering work, the findings from the study I present here are uniquely relevant for understanding engineering practices.

But if we do not look at material and social aspects separately, how can we proceed with an empirical sociomaterial account? The solution, according to Orlikowski (2008), is through a focus on agencies. A theoretical assemblage does not imply that there can be no analytical distinction between the material and the social.[15] In essence, the objective of any sociomaterial account here is to show how artifacts derive their meaning, for both people and their practices, through social agency and social agency in turn is highly dependent on the material world for its meaning-making. Sociomateriality is not about the material going away, but about encapsulating the meaning of the material, how it matters, in practice. The presence of material is less important than how the material is configured in practice and enacted in the moment and the boundaries between the social and the material are constructed and emerge in the moment. The findings from this study show that, analytically, newcomers make use of both social (interpersonal) and material (information technology) resources available within organizations, and their success toward full participation relies on creating a fruitful sociomaterial assemblage.[16]

A case study of InfoLab

Setting

The setting for this case study was an industrial research and development laboratory located on the west coast of the United States. InfoLab,[17] a subsidiary of

longitudinally through entry into the organization and all the way toward full participation and documenting identity change. Despite the popularity of the apprenticeship and communities of practice concepts, few studies have empirically examined newcomer participation. Even the seminal work of Lave and Wenger, *Situated Learning*, which relies primarily on secondary analysis of earlier studies to make their argument, there is limited discussion on the actual practice of newcomer participation.

[12]Orlikowski and Scott, "Sociomateriality".

[13]Lucy Suchman's work has been instrumental in arguing for a sociomaterial view of the world; see Suchman, *Human–Machine Reconfigurations*.

[14]Orlikowski, "Sociomaterial Practices," 1437.

[15]"Any distinction of humans and technologies is analytical only, and done with the recognition that these entities necessarily entail each other in practice," Orlikowski and Scott, "Sociomateriality," 456.

[16]Latour, *Science in Action*; Orlikowski and Scott, "Sociomateriality".

[17]The name of the research laboratory as well as any other identifying information, such as the name of informants, is a pseudonym.

a large Japanese multinational corporation, was founded around 15 years ago and has a considerable reputation for conducting cutting-edge research in the broad area of information sciences. At the time of the field study, InfoLab employed around 20 fulltime researchers and another 20 supporting personnel that included technical support staff, administrative staff, and contractors. InfoLab was headed by a chief operating officer, and two research managers under him oversaw the research staff. The primary research focus in the lab was on interactive technologies and the development of interactive systems. The research topics ranged from the design of a knowledge management system to a three-dimensional browser for viewing images and videos. Researchers had diverse disciplinary specializations as well as different levels of technical competency. The majority of researchers had a doctorate in Computer Engineering, Electronics and Communication Engineering, Computer Science, or a related subject. At the time of the field study, there was an even split between researchers in terms of their education background where half of them had a degree in some sort of an engineering field, whereas the other half had a computer science background. Even the computer science researchers identified more with being an engineer rather than being a software developer and regularly hired software developers as contractors to assist them with the implementation of their ideas.[18] Physically, the laboratory was situated in a larger office complex and occupied the entire second floor of one of the complex's smaller buildings and each researcher was assigned his or her own office space. InfoLab maintained a highly sophisticated technical infrastructure that provided fast, reliable Internet access, state-of-the-art systems for software testing, and databases for storing large amounts of digital data.

Methods and data collection

This study was designed as an ethnographically informed qualitative case study. A qualitative case study design was deemed appropriate given the intent to understand in-depth 'the situation and meaning for those involved'[19] and an interest in understanding the process and not just the outcomes. The goal was to focus on a single phenomenon 'to uncover the interaction of significant factors characteristic of the phenomenon'.[20] I spent five months in the field, from April to September 2005, and conducted 70 formal interviews and over 80 days of observations. All formal interviews were recorded and professionally transcribed, and copious observational field notes were taken. My entry into the field was through an informant interested in my research and I was granted access as an intern with InfoLab. During the fieldwork, I attempted to learn as much as possible about the laboratory and its occupants. I participated in staff and group meetings, lunch and coffee conversations, and any other interactions I could join. I collected archival data that included publications, technical reports, technical memos, intellectual property reports, travel

[18]When the laboratory was formed, experienced researchers with higher degrees in computer science were uncommon and the initial employees, who were hired from other research labs, all had electrical or electronic degrees. At the time of the field study, the boundary issues between those with computer science degrees and those with other engineering degrees were quite palpable but had little influence on newcomers as long as they had their doctoral degrees from a highly ranked institution.

[19]Merriam, *Qualitative Research and Case Study Applications in Education*, 19.

[20]Merriam, *Qualitative Research and Case Study Applications in Education*, 29.

information, monthly activity reports, videos, and dynamic slide presentations with audio. Digital data were pervasive around InfoLab and not only formed the core of the researchers' practice but significantly shaped my field study as well. Access to digital data allowed me to continuously monitor what was going on in the organization through the Intranet and mailing lists and also allowed me to archive data for subsequent analysis.

Newcomer case selection and data analysis

Understanding newcomer participation was a core aspect of my study and I therefore collected extensive in-depth data on newcomers. During the five months I spent at InfoLab, five newcomers joined as fulltime research staff. Of those five newcomers, I have selected the case of one newcomer, Alex, for the purposes of this paper. The participation of this newcomer was unique as he was the only newcomer to actually conduct a demo in front of a large audience, an indication of full participation. Overall, the participation trajectory of all newcomers progressed through the same initial stages. First, they started working peripherally on an existing project with other researchers. Next, they either carved out a piece of that project for themselves or slowly started a project that they would lead. Finally, they presented the results of their work first in the form of demos and subsequently as technical reports and external publications.[21]

I collected multiple forms of data related to Alex's participation at InfoLab. I conducted two formal interviews with him, the first in early May, a few weeks after he joined the lab, and the second in late August, a few weeks before my field study ended. The interviews were transcribed verbatim. In addition to these interviews, Alex was present in many of the interactions I observed around InfoLab and was also a subject of conversations and interviews I conducted with other informants. Furthermore, like the other newcomers, at my request he maintained a diary outlining his interactions with a coworker for a week. Information about his activities was also available through his activity reports, which were filed monthly and archived online. Finally, I had extensive data – including observation notes, audio data, and presentation slides – on the major demo he conducted as well as a practice session he did before the demo. Overall, over five months, I was able to follow Alex's participation from his entry into InfoLab to his first major demo quite comprehensively. Empirically, this study is an example of a nested case study wherein I have selected a unique case for the purposes of this paper from within the large case study of the organization.[22]

Demoing at InfoLab: an important sociomaterial practice

Although the work of researchers at InfoLab was varied and consisted of many important activities such as filing patents, writing papers, and deploying software, many researchers stated that building prototypes and demoing them was more

[21]Alex's case, although the most mature in terms of progress, was not atypical of other newcomers.

[22]As Yin, *Case Study Research* and Merriam, *Qualitative Research and Case Study Applications in Education*, state, selecting a unique case is a valid empirical strategy of purposeful sampling within case study research.

important than any other products they generated. Demoing, which comes from *demonstrations*, is the practice of presenting a designed artifact to an audience in a way that allows viewers to understand the functionality of the artifact through an explicit display of how it works. A demo often incorporates interaction between the demoed artifact and the audience. Demoing, therefore, is a sociomaterial assemblage, an ensemble in which both actors and artifacts played a central and intertwined role.[23] The idea of demonstrating the effectiveness of a technology or product has a long historical tradition but the activity as symbolized by the word 'demoing' is a more recent incarnation. Therefore, this material activity is linked socially to a community of practice in which the use of digital information technology is commonly prevalent. Within the context of a given organization, the performance of a demo itself is a sociomaterial activity undertaken within a specific physical context and with a specific meaning and importance attached to it within the organizational context. A successful demoing requires the person doing the demo to marshal both social and material resources before and during the demo to convey an idea or action to the audience.

Demos were an implicit but important part of the reward structure at InfoLab, as the following quote from a senior researcher suggests, and the importance of demos was echoed in a refrain commonly heard around InfoLab – 'Demo or die'[24]:

> If you don't demo, you don't get rewarded. Those [patents, publications][25] are all useful things to do, but if you don't do demos, you're not going to be as well-rewarded as if you do; it's the perception that you create during your demo that in large part affects your reward.

Demos had become an integral component of interactions among researchers and took place across settings and meetings, such as meetings between group members, forums to discuss intellectual property issues, interactions with higher-ups in the organization, visits by outside vendors, and other events. Demos ranged in importance and demos before organizational members who controlled funding were extremely stressful events with weeks of preparation behind them. On the other hand, early product ideas demoed to close collaborators were informal events often put together in a hurry, but they were significant to work practices nonetheless. For some researchers at the lab, demos and demoing had become a practice they preferred over other products and practices at InfoLab, as Chris, a researcher who had been with InfoLab since its inception, stated:

> Demos are our product and the people who see them are our customers. So, if we get high-ranking executives from Japan or something, this is our, this is what we do, this is what we produce, this is what we create, this is our return on investment or something like that. So, there's a more fundamental product than other people acknowledge; I think a lot of people see demos as kind of means to an end of technology transfer or businesses or something, but I kind of see them as an end in themselves.

[23]Latour, *Science in Action*; Orlikowski and Scott, "Sociomateriality".
[24]This slogan is usually attributed to Nicholas Negroponte, who used the phrase to emphasize the importance of doing and building in computer science against the popular tradition of writing technical papers and theorizing, quoted in Markoff, *Nothing Up Their Sleeves?*.
[25]Words within square brackets are inserted in order to make the meaning of the quotes clear. Ellipses within square brackets, such as [...], signify that the quote has been truncated by removing text.

A demo consisted of two essential components. First, a prototype of a system that varied from a fully functional interactive model to a dynamic or static visual representation that could convey the functionality of the system. Second, demos involved explaining the utility of the system through talk or, as was more common, through a combination of visuals and texts often using the presentational software PowerPoint™. Demos were more than product displays; they were performances wherein the product had a major role and was presented to the audience with a specific purpose in mind. The presenter used the right mix of verbal, visual, and interactive elements to persuade the audience of the value of the designed artifact.

Given the importance of demoing at InfoLab, it was not surprising that the practice was a critical component of newcomer participation. For a newcomer to be able to come up with a novel idea and develop a prototype to display the importance and originality of the idea was a significant milestone as it depicted their disciplinary knowledge as well as the ability to contribute to knowledge construction within a community of practice. Using demoing as an exemplar of newcomer participation, I now describe how one newcomer, Alex, moved from peripheral to full participation at InfoLab through his participation in the practice of demoing.

Newcomer participation into demoing

Alex had recently received his PhD in Electrical Engineering from a large university in Midwestern United States when he joined InfoLab. During his doctoral studies, he was a member of a large research group that worked on image processing. He was proficient in software programming but viewed it as a literacy required to develop prototype that could be used to demonstrate his ideas. He emphasized that large-scale implementable versions of his products were always going to be engineered by professional software developers. He was in his late 20s and had moved to the US from Asia for his graduate studies. Although English was not his mother tongue, he was a fluent speaker of the language. Within two months of joining InfoLab, he was given primary responsibility to demo his work as part of an intellectual property meeting within the laboratory. Although I had observed other newcomers present their work in group meetings, they did not do so outside their groups. To understand his participation and consequent successful demo, it is important to discuss his experience before he formally joined InfoLab, starting with the job interview. After discussing his job interview process, I examine his participation by exploring the following stages of his trajectory: entry into InfoLab, ideation, procurement of data, creation of prototype, preparation for demoing, performance of demo, and the subsequent construction of knowledge. Although for analytical purposes, I make clean distinctions between the different stages, in reality many of the stages overlapped. These stages, which are summarized in Table 1, emerged from the data and therefore although they might be applicable to other contexts of newcomer participation, they are not meant to be a 'model' in the strict sense of the world. Variations across settings and even within a setting are to be expected.

Stage 0: The job interview

The importance of presenting one's work to an audience – preferably through a demo – was impressed upon Alex as early as his job interview with InfoLab. A critical component of the hiring process, the research job talk was a sociomaterial

Table 1. Stages of participation and sociomateriality.

Stage	Core sociomaterial element(s)
0: The job interview	Involved a presentation open to all researchers in the laboratory; required individual meetings with most researchers in which, in addition to talk, the interviewee would often present work informally on a laptop
1: Entry into InfoLab and uncertainty reduction	Interacting with others in a new physical setting; figuring out the norms of use of different physical spaces; observing others presenting their work and interacting while presenting
2: Ideation	Creating new materials within the context of his research group; seeking legitimacy within his research group by showing his materialized ideas
3: Creating infrastructure to generate data	Figuring out what materials and data were available in the lab by communicating with other researchers; making plans to procure new data in a manner where others supported him; creating and laying out the material infrastructure with help from others; generating and storing data while working with the person responsible for data permissions
4: Creating a prototype using digital data	Working with others to understand the overall design and functionality of the intended end product; translating the requirements into software code and getting feedback on different iterations
5: Preparing for the demo	Communicating with others to understand the purpose of the demo and the norms of the IP meeting; creating and testing a prototype that is relatively stable, attractive, and able to demonstrate and convey the essential functionalities of the intended product; practicing the demo by performing in front of an imaginary audience in the room in which the demo has to be given
6: Performance of the demo	Performance in front of lab researchers; interaction with audience to explain approach and product
7: The sociomaterial construction of knowledge	Assimilation of feedback received during demo and its incorporation in the next iteration of the product; intellectual property development in two different directions based on feedback

experience that involved interactions with researchers as well as physically setting up to give the talk. In Alex's case, he met in the morning with his initial contact, his host, who gave Alex a list of all the people he was to meet with. Subsequently, Alex set up his laptop in the conference room and presented his job talk. Due to the materiality of the talk, interviewees were given ample time before their talks to prepare. As one senior member put it, 'We've had technical difficulties before', so giving the presenter time to set up the presentation was critical. Most of the speakers used PowerPoint™ presentations with some interactive features. If a candidate had developed a prototype, they usually demoed it during the presentation. Demos also

allowed InfoLab members to assess the programming or development skills of interviewees, as building a demo required extensive technical skills. The talk was used to judge a candidate's presentation skills, their clarity of thought, and the quality of their responses to audience questions. The job talk was an indicator of the ability of a candidate not only to construct new knowledge but also to engage with their disciplinary community to articulate the contribution of their work to the disciplinary body of knowledge. Needless to say, during their graduate training most researchers had a similar experience while presenting their work to colleagues at conferences or in research groups. During my fieldwork, I attended a couple of job talks – which were not usually open to non-research staff – and was able to view archival videos of talks by other newcomers. All talks were highly polished and well rehearsed: the presentation slides were well designed and aesthetically pleasing, and the interviewees chose their words carefully and spoke with confidence. The job talk was usually the only hiring-related event where all lab members were present, and therefore it became the key decision point in hiring. As the above description indicates, the sociomateriality of participation was evident from the very start of a prospective researcher's contact with InfoLab. Therefore, there was some continuity in the graduate training of the newcomer and expectations in the research lab but the actual importance and practice of presenting one's work differed significantly, as I will now show.

Stage 1: Entry into InfoLab and uncertainty reduction

Once Alex officially joined InfoLab, his initial days were full of uncertainty and ambiguity. Like any newcomer, Alex keenly observed the world around him and weighed his options around what practices to participate in, deciding which were crucial, and then figuring out ways to start engaging in those practices. That demoing was a critical practice which was something newcomers learned by observing other researchers' actions and by ascertaining what other researchers thought was important. Alex's strategy was to engage in different projects and then figure out a way to make an individual contribution by demoing his idea and products. I now turn to those particular aspects of his experience.

Alex quickly started collaborating on several projects. A month after he was hired I asked him what he had been doing since he joined InfoLab, and he listed three different activities in which he was involved. He was working with another researcher, Gavin, to develop a method for classifying information recorded through a projection capture system. Alex proposed and developed a prototype that performed better than previous methods. He was also working on a project on collaboration using video cameras to help in information detection. And finally, he was working on a project on security to help capture information about people and events.

When Alex joined the lab, Gavin was assigned to him as a mentor. The mentor's job was to help orient the newcomer during the initial period. During their early discussions, Alex and Gavin realized that Alex could contribute to Gavin's ongoing project. Apart from assigning a mentor to help with initial acculturation, InfoLab did not have a formal training structure for newcomers. Its small size facilitated informal networks and interactions yet newcomers experienced a lot of uncertainty. The senior researchers were aware of this issue but regarded it as a normal part of socialization in which a newcomer had to establish and form an identity. As one

young researcher, Brent, who had joined InfoLab a couple of years prior to Alex and was trying to involve Alex in his ongoing project, put it:

> I think it's an interesting time for, I think, everyone who comes here, because you don't get a lot of direct ... no one sits you down and says, "Do X." That's just not how the lab works. [...] But because we are kind of prima donna researchers, everyone has their own routine, their own schedule, and so that's why I'm trying to pay attention and get [Alex] involved in the project if he wants to be, just so that he has something to sort of focus on while everything else settles into place, hopefully. We'll see how it goes. When I first came here, I remember kind of just trying to figure out what I was going to do for a decent while.

Since newcomers received minimal guidance from senior researchers, they took time to understand the organization and decide on their path within InfoLab. This sensemaking was particularly evident in the choice to follow an applied path versus a more traditional theoretical research career, as Brent explained:

> So that's what is interesting for a guy like [Alex], he's going to have to come here and decide, "Do I want to try to write papers and be a more traditional researcher? [...] Do I want to be like a more academic kind of researcher or do I want to be someone more applied and try to build systems that aren't going to be hard to convert to products?"

The choice was not necessarily clear-cut; the problem with being an applied researcher, as Brent saw it, was that it required concerted effort to convince managers of the value of one's product, assuming the researcher was able to identify a good business need. Furthermore, Brent saw it as an identity issue: 'Most of us have been trained to be academics rather than do all those other things'. Following the path of an applied researcher at InfoLab implied developing the ability to demo. The significance of demos was not only reiterated in many of my interviews with researchers but was also formally recognized. The number of software products developed and subsequently transferred toward actual production was a metric that was taken into account during the annual review of researchers. Therefore, the ability to develop demos quickly was considered a very valuable expertise and every research team within the lab wanted to hire or acquire at least one researcher who could do so.

The uncertainty around newcomer socialization, that Brent describes here, was further evident from Alex's week-long diary detailing his interactions with a coworker. The coworker he selected, James, was an alumnus from his graduate institution whom he had contacted before joining the lab and with whom he had also started collaborating on a project. Most of his interactions with James were one-on-one, face-to-face unplanned interactions that occurred in the office, in the kitchen, and on the balcony where many researchers had their lunch. They talked about Alex's project, his current tasks, and other coworkers. Alex reported in his diary that through these interactions he learned about James, other coworkers, his project, and the lab. He reported that 'future directions for research' was a critical topic during these interactions. The two also talked frequently about an important upcoming event, the intellectual property meeting. Through the diary and the record of his monthly activities archived on the InfoLab Intranet (Table 2), it became evident that during his initial months, Alex became engaged in multiple projects as he tried to make his place in InfoLab. His initial days at InfoLab were marked by uncertainty and he spent considerable time trying to make sense of his new world.

Table 2. Newcomer activities reported by Alex in his 'Monthly Activity Report'.

Month	Activity
April	Newcomer joined the lab and quickly became involved in group activities. With other researchers, he discussed an interface to control multiple cameras in a complex environment. He implemented a system to detect corners that can be used to calibrate multiple cameras. He further made plans to purchase equipments to collect data. Working with another research group, he implemented an approach to classify images which seems very promising
May	Participated in group collaboration to compete in a video analysis competition. He set up a temporary video system that mimics a surveillance system and captured some video. He applied algorithmic techniques. Worked on developing a user-friendly interface with a couple of other colleagues. Worked with a senior researcher on new analysis software
June	Worked on the user interface of a system to analyze and monitor videos. The system uses a 3D interface. Submitted an invention proposal
July	Worked with other researchers and an intern on video analysis system. Set up network cameras to capture videos for a security project. Implemented post-processing in collaboration with a senior researcher. The intern he worked with presented his work at an interns meeting. Officially submitted an invention proposal, one technical report (single author) and a technical memo (with two senior researchers)
August	Continued work on video competition with intern and other senior researchers. Improved the user interface of his video system and demonstrated the system using three weeks of data. Worked with attorney to file two patents. Submitted a journal paper. Met with external visitors

Stage 2: Ideation

Alex finally narrowed down his interest to focus on a project that involved applying computer vision technology to improve security. Specifically, he came up with a way to enhance the interface for security video monitoring. The group he was a part of was starting to add video surveillance as a research area, and Alex selected one aspect of that project for future work. Although the overall research idea was driven by many decision makers within InfoLab, participation in the external research community played an equal if not a more important role in Alex's ideation process. At one of the premier conferences in his discipline, he found that security-related applications were, according to him, 'getting a boost', which gave him the momentum for his project. Although his coworkers advised him that there was already a lot of work in the security research area, at the conference he found out that most of the work was in nascent stages and he could easily catch up. Furthermore, at the conference, he was exposed to another system related to his idea that provided him with information on how to distinguish his efforts from previous work. He had already learned from prior work experience[26] as intern at another research lab that solid background review before embarking on an ambitious project was critical. The ability to differentiate a product from others becomes a decisive part of the overall discourse when presenting an idea. When Alex presented his idea and demo at a later meeting, he made it a point to mention the competitive product and then highlight how his idea was unique. The sociomateriality of outside

[26]Prior work experiences, even of very short time periods, were an important resource in shaping newcomer socialization. Alex frequently compared and contrasted his initial days in other work situations with his initial days at InfoLab.

interactions was evident in this aspect of knowledge construction, as participation in the outside research community not only to exchange ideas but to evaluate products was critical for creating novel products. Therefore, newcomers were expected to interact with researchers outside the laboratory and participate in conferences and workshops. Alex availed himself of this opportunity and was glad to find external validation for his new line of research into security.

Stage 3: Creating infrastructure to generate data

Once Alex had decided on the product, the next step was to procure or collect data for demoing the security system. Similar to physical and biological scientists' lab work involving collecting specimens or growing bacteria colonies for experimentation, Alex had to create enough video data so that he could run his algorithm and show some results when he presented his work to other researchers. This process started with him setting up cameras to record video that could then be used as data for the software he had developed. I observed him talking with an old-timer who was giving him a tour of the lab and showing him miscellaneous hardware and other material that he could use for his camera setup. Alex initially said that his manager had suggested putting cameras in the conference room, as that was where a lot of activity occurred. The old-timer politely vetoed this idea by saying, 'That's something worth thinking about. The [CEO] doesn't like wires, especially in conference rooms'. The newcomer then asked for some tripods and the old-timer responded, 'Adam is the keeper of tripods and stuff'. Through this informal conversation, Alex was learning about other people around the lab and their preferences and roles.

Based on the old-timer's feedback, Alex decided to not record events in the conference room and instead installed the cameras in the hallway (which I noticed on my way in to work the next day) and in the copy-and-print room. These video data formed the core of the prototype demonstration at the intellectual property meeting. Alex later sent an email about the project to all lab members. This email gave details about the project and asked them for their consent to collect the video data. But things were not as easy as he had hoped. In my second interview with him, which occurred after his demo, he discussed some of the difficulties he had faced, saying, 'It wasn't very smooth, because, first of all, there is deterrent from people's worry about privacy issues'. He had been under the impression that a professional contractor would be on hand to help him install the wiring for the cameras, but he quickly realized that this was not the case and according to him he ended up spending 'an enormous amount of time' installing the cameras himself. He did not get much assistance from his colleagues during this stage. In addition, he had difficulty getting his permission form signed as he was not aware of the process of getting approval for collecting video data at InfoLab (many informants commented to me that his email asking for permission had a 'harsh' tone), and one researcher refused to sign it. What this meant was that he would have to go through all the video data looking for this person and then cleaning the data by masking the identity of the researcher who had refused to consent. Overall, creating the infrastructure that could generate the data he required to run the software he had developed turned out to be an arduous task for Alex. The process was not only cumbersome, but demonstrates the close interaction between the social and the material. The material data he needed required working physically with wires and cameras but the process was equally

dependent on managing the social: gaining permissions to record the video and gaining help in procuring the material.

Stage 4: Creating a prototype using digital data

Once Alex got all the logistical issues sorted out, he worked for extended hours on the prototype. He expressed mixed emotions about this situation and quoted another newcomer who told him that researchers are not supposed to work overtime. He justified his effort by saying that he was a highly self-motivated individual and even though working extra would not lead to extra monetary compensation, he would be able to reach his goal faster, which was extremely important to him. He then narrated his prior experience working as an intern with the research lab of a large multinational corporation; he noted that in that very competitive environment his internship project was one of the final 10 selected to be presented to the CEO.

During the interviews with me, he talked extensively about his programming and algorithm design experience and explained that given his prior experiences and expertise he was quite comfortable with this aspect of his work. Still, he faced many obstacles, as he still had to struggle over decisions about programming languages, and he lamented the fact that there was very little or no programming code available for reuse and so he had to do all programming from scratch. Usually, in an industry or academic setting when a group works on software development over time they create a repository of software code that can be reused when new programs are to be written or new features have to be added to software. He commented that during his graduate work, he was easily able to access software code from other members' of his research lab and reuse or modify the code as needed without having to develop it from scratch. Given the novelty of Alex's work, in which he was attempting to create a system for video monitoring for security, there was very little prior work in the area within InfoLab, making the research process time-consuming compared to his prior experiences:

> [My research] group [at my Ph.D. granting institution] used to concentrate on image retrieval and user interface, so they don't do a lot of hard-core computer algorithm. And in that sense they [InfoLab] don't have a large repository of existing system or existing code, which is both good and bad: good in the sense that I can do, I have a fair amount of liberty to choose the direction to go; bad in the sense that I have to do a lot of dirty work to do the basic coding and system building.

This issue was further complicated by the need to later incorporate his work within existing technologies at InfoLab and develop a stable prototype. In his interview with me, Alex reiterated the problems he was having in managing his time and complained about the long hours he had to spend on developing the prototype. He even had to work over the weekend, something that was not the norm at InfoLab. Overall, creating the prototype through the use of digital data involved working alone for the most part but still the social context he was in played an important role. In particular, the context of his work defined how he interpreted his efforts – working a lot compared to others – and the help he could get in the material aspect of his work, the code, which was not very forthcoming given that the work he was doing was relatively novel compared to previous work done by researchers at InfoLab. This was significant since although Alex was

putting in the majority of effort into system development, technically he was working with other researchers in the lab who were part of his research group. But, as he would later realize, invariably the lead researcher on a project ended up investing the maximum amount of effort and other team members played more of an advisory role.

Stage 5: Preparing for the demo

In spite of the uncertain environment he had faced since joining InfoLab, Alex quickly developed a workable equilibrium and was productive at his job. His progress was strongly signaled by a demo he gave two months into his tenure at InfoLab. His demo was part of the laboratory's intellectual property meeting which was held every couple of months to discuss new ideas and products that could be patented by InfoLab. The purpose of the intellectual property meetings, or TIPs, was to ascertain the value of an idea or product in order to determine whether the idea warranted intellectual property protection before it could be shown or published publicly. Each patent filed by InfoLab cost about $25,000, and therefore it was critical to assess the novelty and patentability of ideas before starting the legal process. The TIPs were highly technical affairs during which each patent idea was vetted by a committee and then presented before all research staff. Each idea or prototype was assigned a reviewer who did background research on the idea and then led the discussion that followed the researcher's presentation. The process also required considerable time and effort from the researchers themselves, including extensive conversations and meetings with patent attorneys.

Alex prepared hard for the TIP meeting. He submitted his ideas to the intellectual property committee, which was responsible for organizing TIPs, and then met with the reviewer assigned to his idea to talk about how and what to present at the meeting. Once he developed the prototype, he prepared a PowerPoint™ presentation to use during the meeting. I observed him practicing his presentation in the conference room where the TIP meeting was to be held, five minutes before the actual meeting started. He stood in front of the room and went over his presentation slowly, talking in a low voice to an imaginary audience. In many instances, he repeated different variations of the words he was going to use with each slide. He spent significant time on the opening lines of the presentation (see Figure 1) until he felt comfortable. As he practiced the lines he was going to use, he also made modifications in the presentation slides in order to synchronize his speech with the visual and textual representations on the slides. In addition to the presentation, he also briefly ran the digital prototype he had prepared in order to test that it worked. In all other areas, Alex showed signs of self-assurance, but he was not confident about his skills as a presenter. At one point during an interview with me, he said that he practiced presentations a lot both because English was not his first language and because he did not consider himself to be a very social person. Overall, Alex realized the importance of the demo he was going to give and therefore made significant efforts to prepare for it. In addition to the presentation and display of software, demoing was a social practice, and once he had the requisite data to run his software, he undertook a trial presentation to tweak the material so that it was aligned with the social – that is, so that the text, visuals, and software were accessible to his audience.

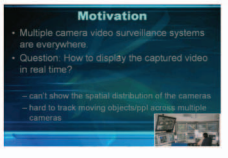
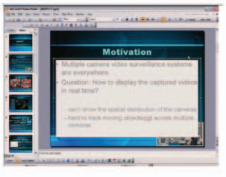
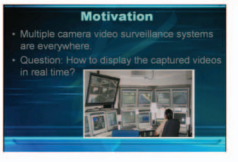
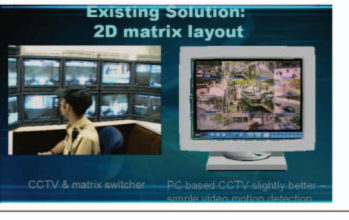
PRACTICE TALK (Alex talking to himself) (07/13; 2:00-2:30 PM)	ACTUAL TALK (07/13; 2:50-3:30 PM)
Slide 1: Title Slide Good afternoon ladies and gentlemen today I'm going to talk about my invention proposal on immersive user interface for analyzing and monitoring videos from multiple cameras the short for this project the abbreviation code name for this project is INSPECT which stands for intentional surveillance of people by content analysis…by content analysis. [Long pause while he is working on the keyboard and murmuring…says "switching"…trying to figure out the system].	***Slide 1: Title Slide*** Good afternoon everybody [brief interruption due to cross talk among the audience] good afternoon everybody today I'm going to talk about this immersive user interface for [pauses] analyzing and monitoring videos from multiple cameras. The shorthand for this project is called INSPECT basically intentional surveillance of people by content analysis.
Slide 2: Motivation The motivation for this project is to…the motivation for this project is to solve the problem …motivation of this project is to try to…improve the user interface of current control room monitoring set up…current surveillance systems. Basically after the September 11th and everything after the September 11 after the September 11 attack US and US security alert in the US and UK has been surging to a level that has never been surpassed that has never been surpassed of since World War II and many surveillance camera systems are prevalent. During the recent London train attack London train attack analysis team analyzed videos and found suicide bombers gathering taken at the train station.	***Slide 2: Motivation*** So why do we do this? Because surveillance is everywhere. After September 11 people are getting more nervous about terrorist attacking public places business locations as well as home security. And the current solution is something like this multiple displays in a control room. It is hard to direct attention for the user to track an object across multiple displays is practically impossible. So the question remains how to display multiple videos in real time.
  Changes the slide by editing the content and making the embedded picture larger (final edited slide is presented in the righthand column)	
Slide 3: Comparison of Existing Solution (2D matrix layout) and Novel Approach	***Slide 3: Comparison of Existing Solution (2D matrix layout) and Novel Approach*** Removes overlay text on pictures
	
Slide 21: Demo Maybe now it's time to show some demo 	***Slide 20: Demo*** So, here comes the demo Slides same as practice talk

Figure 1. Comparison of Alex's speech and slides during the practice talk and the actual presentation.

Stage 6: Performance of the demo

The official time of the TIP meeting was 2:30 p.m. Around that time people started to enter the room; the meeting officially started at 2:35 p.m. When the meeting started, 18 people were in the room (the room had a capacity of around 40 people). After the first presentation, which took about 10 min and was done by an experienced researcher who talked about patenting an application related to audio transcription, there were some questions and discussion. The first presenter's ideas were in the early stages and he used only PowerPoint™ slides with figures and explanations of how his idea would work, as opposed to actually demoing a system. These kinds of presentations were common at TIPs meetings, but there was an understanding that they were early-stage ideas that needed significant work before they could be patented. From the researchers' perspective, feedback on the ideas was important in order to gauge if there was any interest at all or if they should stop pursuing the idea. Alex's presentation started around 2:50 p.m. Right before the presentation he left the room, so that when his name was called he was absent from the room. At this someone remarked, 'He escaped!' and everyone laughed. As Alex reentered the room one of his project mates, James, said, 'You are up', and Alex went straight to the front of the room. His total time at the podium was 40 min, including the PowerPoint™ presentation, his demonstration of the prototype, questions during and after his presentation, and a longer discussion at the end. His presentation – both the words themselves and the look and feel of the slides – was different from his practice run earlier in the day (see Figure 1). The interaction with a real audience changed the flow due to interruptions, as Alex had to take time to respond to each question.

The intertwining of the social and material was evident during Alex's presentation in the listing of names on the title slide. He expressed concerns about whom to credit in his presentation, which also implied co-authorship of the intellectual property application that would be filed. He said that he was very accommodating and had listed a lot of names, including those of some people who only helped him at the last moment. He told me in an interview after the demo that because he was new and was trying to build collaborations and partnerships, he was fine with 'playing their games', meaning, giving credit to others even though he was not sure that they deserved it. The lab was known to be very inclusive in giving credit to other researchers, and Alex was able to pick up on this aspect of lab practice. Interestingly, even other researchers were skeptical of the practice of listing authors inclusively. During Alex's presentation, the person running the TIP meeting asked one of the people listed on the presentation to clarify some technical aspect of the project and he responded, 'I don't know, he [Alex] just put my name up there', and the room burst out laughing. When I asked Alex why he had added this researcher's name, he replied that this person had actually made a significant intellectual contribution which was more than what many others who were listed as collaborators had done. This incident illustrates the highly inclusive authorship custom at InfoLab, a work practice that Alex picked up early on in his tenure. Overall, Alex's performance of the demo turned out to be successful as he was able to balance the material (presentation slides, software) and social (talk and interaction) quite well. He demonstrated the ability to reason with the help of a physical product, thereby displaying his mastery of the ideology of demoing at InfoLab.

Stage 7: The sociomaterial construction of knowledge

After the TIP meeting, I interviewed Alex and he said that he was quite pleased with the presentation and the demo and observed that his experience was relatively smooth compared to other researchers who also presented their ideas at the same meeting. In addition to Alex, four other invention ideas were discussed in the TIP meeting. The first idea was relatively rough and the researcher received feedback to work more and submit his idea again. Another researcher presented an idea on a topic similar to Alex's, video analysis, but was criticized by many researchers for the lack of novelty in his idea and its implementation. Two additional ideas were presented in the meeting and they were criticized for being too theoretical and were also received less favorably since they did not have software that was ready to be demonstrated. At the end of the meeting, Alex's idea was deemed ready to be filed for invention disclosure, and after some resistance the other idea on video analysis was also accepted. The rest of the ideas were rejected.

Despite his success, Alex realized that one of the more important outcomes of the demo had been the interaction he had during the presentation and suggestions he received from other researchers to improve his product. He said that based on the feedback he received at the meeting he had already started 'tweaking' his software code and was looking at some other algorithms. He explained that his primary goal in the near future was to develop a working system that he could use in different research modules and that he already had a concrete idea of how to go about it: 'the tracking part, the segmentation part, the user interface part can all be improved and each of them will be one or more [patents]. Along the way, I will be also publishing everything'. He said that the discussion at the meeting and the comments from other researchers had given him several ideas. Primarily, there was consensus at the meeting that Alex should split his efforts along two different lines of research and file for separate invention proposals for each. Overall, Alex's work, although remaining consistent with his initial ideas, took a slightly different direction after the TIP meeting, illustrating the joint construction of knowledge through display at the public stage. Demos at InfoLab were events that served the purpose of engaging other researchers in the process of thinking and brainstorming about an idea. This was an essential phase of knowledge construction at InfoLab. Demos functioned as cognitive devices that allowed the audience to better understand the actual functioning of a product, as opposed to a mere description of how it would work, thereby allowing them to make more constructive and targeted suggestions for improvement. Not unlike the social construction of facts in scientific research,[27] demos were sociomaterial constructions of ideas.

Figure 2 illustrates Alex's trajectory of participation from his entry into InfoLab until his first successful demo. It shows the sociomaterial nature of his participation which culminates in with a successful display of demoing and the resultant knowledge construction through incorporation of feedback he received during the demo. To further ascertain the nature of Alex's participation, I interviewed him and researchers he worked with after the demo. Alex remarked that after the demo he was able to showcase and discuss the work he had done within his research group and even to some external visitors and felt that he was becoming more engaged with other researchers and their projects. Several researchers commented on how they had leveraged Alex's expertise and enthusiasm for their projects. Alex was able to

[27]Latour and Woolgar, *Laboratory Life*.

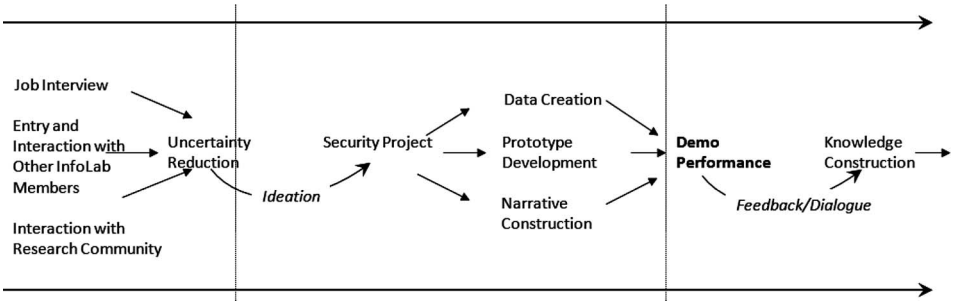


Figure 2. Alex's participation trajectory from entry to full participation (adapted from Johri, 2007).

develop the system fully and patent it and subsequently developed another video-based system that was deployed across multiple sites in Japan and generated significant revenue for the parent company.[28] Although it is hard to pinpoint the precise moment when someone becomes a full member of a community of practice, Alex's overall trajectory suggests that not only was he able to enter the community of practice but gained a status of a full member.

Discussion and conclusion

In this paper, I show how a newcomer traverses his early days in a research laboratory and moves from peripheral to full participation in his community of practice.[29] Alex successfully navigated the organizational and social context of InfoLab and productively used the materials available to him. If the materials he needed were not readily available, he constructed them, such as the data for his demo. He assembled the demo from a range of artifacts – visuals, animations, texts – that he generated or acquired from others as well as through his ingenuity, and he performed the demo successfully. The success of the demo was validated by the filing of two patents based on this work. At InfoLab, demoing was one instance of this amalgamation, a 'sociomaterial assemblage'. Text (visual and aural), images, video, pictures, animations, and direct manipulation were all key components of this assemblage and were used judiciously by Alex to showcase his work. Demoing was a complex activity often serving as the primary indicator of both disciplinary and technical competency among researchers. Demos combined the technical competence required to build a working system with the social competence to understand the audience and users of the system and to present a working prototype to other researchers. Although for analytical purposes, it is important to distinguish the social and material – such as the data versus who he gets the data from or how he generates it with the help of others, in practice, and for Alex, this distinction did not exist. He enacted both the social and the material in a mutually constitutive

[28]This system was developed after I had completed the field study but I was informed about it by several informants with whom I was in touch after the field study was officially completed. Alex's success in terms of product development signals his interest in more applied research; whether to work on theoretical problems or applied research was an issue that he grappled with initially but he came down firmly in favor of applied research.
[29]Lave and Wenger, *Situated Learning*; Wenger, *Communities of Practice*.

manner.[30] This case study sheds significant light on the process of learning within a community of practice. In addition to accepted issues of identity transformation and norms, this case study illustrates the sociomaterial nature of participation.[31]

What did Alex learn through his participation? First, through enactment of accepted practices within the community of researchers at InfoLab, he demonstrates his transition from a peripheral to a full member in the community and also shows that he has learned *how* to become a member a community of practice. The demo signaled his fuller participation in the community. Second, his movement from peripheral to fuller participation itself is a form of learning as through this process he undergoes an identity change from a newcomer to a more established member of the organization.[32] Third, the feedback on the demo and subsequent knowledge construction, as well as working on the demo in the first place, resulted in gains in technical knowledge and contribution to the research lab. He reported that he learned a lot from his participation including how to develop and file a patent, how to apply his technical skills to a new content domain, and how to initiate and grow new areas of expertise.

In addition to showing the sociomaterial nature of newcomer participation, this case study of Alex also sheds light on the changing nature of engineering work. The boundaries between the social and the material have become increasingly fluid and malleable with the advent of digital tools and technologies. As reported by several scholars,[33] over the past couple of decades the engineering workplace has become more digitized through the use of simulation tools and digital communication products. This change has given rise to new forms of working, such as geographically distributed and virtual work[34] and emerging disciplines such as information sciences, which include disciplinary areas, such as information systems, human-computer interaction, knowledge management, social computing, and computer-mediated communication. The boundaries between traditional engineering disciples, as institutionalized in engineering departments, are being blended as computer science is becoming integral to more and more engineering disciplines. In engineering research laboratories, digits – that is, computer code – form the primary substrate of work with respect to input as well as output, and physical and digital materiality is omnipresent, weaving itself into the fabric of the organization and its practices. This is seen in the technical work as well as the representation and communication of work. One manifestation of this is the shift in scientific discourse to include visuals, both static and dynamic, at a much larger scale than previously possible.[35] This case study also depicts this shift within engineering research practices.

[30]This intricate relationship between the social and the technical in engineering practice has also been brought to attention by Trevelyan in his studies of the engineering workplace. See Trevelyan, ''Reconstructing Engineering from Practice''.
[31]Johri, ''Sociomateriality of Learning Practices and Implications for the Field of Learning Technology''.
[32]Lave and Wenger, *Situated learning*.
[33]Schmiede and Will-Zocholl, ''Engineer's Work on the Move''; Campagnolo and Fele, ''From Specifications to Specific Vagueness''.
[34]Johri, ''Sociomaterial Bricolage''.
[35]Lemke, ''Multimedia Genres for Scientific Education and Science Literacy''; Pauwels, *Visual Culture of Science*.

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