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ABSTRACT

Employers and policymakers have traditionally sought to manage skill shortages in technical and other occupations through initiatives predicted in one of two broad definitions of skill: skill-as-input and skill-as-artifact. A weakness of both these perspectives is that focusing on the inputs and outcomes of a labor process obscures or ignores the process itself. These two perspectives could be complemented by considerations of skill-in-practice. Recent attempts to address the growing demand for medical technicians and technologists illustrate how a practice-oriented approach to skill might shed light on the nature of skill shortages and lead to more effective policy. In response to skill shortages in medical technology, Congress has proposed two bills: the Clinical Laboratory Improvement Amendments (CLIA) calling for increased technical education, and the Rural Clinical Laboratory Personnel Shortage Act, which would relax some of the stringencies of CLIA. Medical technicians and technologists endorse the bill designed to downgrade skill requirements; physicians favor the bill aimed at enhancing skill requirements. The technicians' endorsement may reflect their conviction that the bill is more congruent with the work they actually perform. An ethnographic study investigated technicians' definitions of skill-in-practice and the implications for resolving skill shortages in technical occupations. At the hospital observed, the technicians' notions of skill were based not on education or job design but on specific work practices: ability to troubleshoot machines, demonstration of improvisational techniques, and social pooling of knowledge and experience to interpret ambiguous results. (Contains 52 references.) (YLB)

EQW WORKING PAPERS

Button Pushers and Ribbon Cutters: Observations on Skill and Practice in a Hospital Laboratory and Their Implications for the Shortage of Skilled Technicians

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"Button Pushers and Ribbon Cutters: Observations on Skill and Practice in a Hospital Laboratory and Their Implications for the Shortage of Skilled Technicians"
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I. Introduction

In recent years, technical occupations have begun to comprise an increasing proportion of the total U.S. labor force (Silvestri and Lucasiewic 1989; Johnston and Packer 1987). The exponential expansion of scientific knowledge over time, coupled with rapid and widespread technological change and including the rise of the computer, has fueled a growing demand for scientists, engineers, and technicians and has prompted the emergence of entirely new technical occupations. According to Barley (1991, 5), "Over a quarter of all new jobs between 1990 and 2000 are anticipated to be professional or technical jobs. If, as some labor economists argue, the government's estimates are conservative, then professional and technical occupations may represent as much as 20 percent of the workforce by the year 2000." In light of these trends, employers have warned that the workforce is insufficiently skilled to meet the rising demand for technical workers and that eliminating such skill shortages must become a national priority (Bishop and Carter 1991). To date, however, little is known about the skills that technical jobs require or how these skills are acquired and transmitted.

Employers and policymakers have traditionally sought to manage skill shortages in technical as well as other occupations through initiatives predicated on one of two broad definitions of skill (Attewell 1990; Vallas 1990). The first approach has been to define skill as the formal knowledge and abilities that individuals apply in the transformation of raw materials to some finished product. By treating skill as if it were an attribute of individuals, skill can be reduced to "a necessary input to the efficient production of goods" (More 1982, 109). I will refer to this school of thought throughout the paper as the "skill-as-input" approach. Because the skill-as-input perspective draws attention to the formal knowledge workers possess, it often leads researchers to equate skill with educational attainment. The more education people have, the more "skilled" they are presumed to be. Researchers who consider skill to be a personal attribute have accordingly relied on educational attainment as a measure of skill (Becker 1975; Field 1980). Similarly, policymakers supporting this notion of skill have sought to manage skill shortages by concentrating their efforts in the realm of education.

A second approach has been to treat skill as if it were a by-product of technology rather than a characteristic possessed by an individual. According to this view, workplace technologies largely determine the skill requirements of jobs by generating tasks that vary in complexity. Technologies that create jobs composed of complex tasks are said to simultaneously generate a demand for skilled workers. Conversely, technologies that produce jobs entailing simple tasks require relatively unskilled labor. When defined in this way, skill is essentially reduced to an artifact of existing technological arrangements in the labor process (Kerr et al. 1964; Bell 1973). Throughout this essay, I will refer to this view as the "skill-as-artifact" approach. The focus on task complexity inherent in the skill-as-artifact approach has led researchers to rely upon formal job descriptions and occupational groupings as measures of skill (Wood 1982; Kohn and Schooler 1983; Flynn 1988). Similarly, it has led those seeking to reduce skill shortages to concentrate on job design rather than education.

There are two major shortcomings common to the skill-as-input and skill-as-artifact formulations: the first is epistemological and the second pragmatic. First, both approaches treat skill as more or less exogenous to the labor process, in one case as an input and in the other as an outcome. Such a treatment enables researchers to concretize skill by equating the concept with formal knowledge and task complexity. However, in adopting this practice, researchers also risk reifying the concept of skill. By reification, I refer to the process of reducing a relatively abstract concept to a "thing" that can be isolated and identified: in one case as a credential and in another as a sequence of tasks. Reification enables researchers to assume that skills are "objective" and hence more easily observable and ultimately measurable entities (Spenner 1983, 1990). However, reification also leads researchers to act as if skill can be assessed without considering the context of the work itself. As a result, researchers may obscure the true essence of skill by divorcing the concept from what it is people actually do on the job.

In addition to being epistemologically suspect, the skill-as-input and skill-as-artifact approaches are troublesome on purely pragmatic grounds. Although skill-as-input and skill-as-artifact definitions suggest very different methods for addressing skill shortages, both generate solutions which may ironically exacerbate the problem. Proponents of an education-centered response all too often argue that workers simply need more education and better credentials in order to meet the requirements of technical jobs (Parnell 1985; Bishop and Carter 1991). In some cases, additional formal education may indeed be necessary. However, when the formal knowledge transmitted in schools and training programs is mismatched to the actual work of technical occupations, an education-centered response is bound to fail. Collins (1979) demonstrated that in many occupations, the linkage between formal education and skill is at best tenuous. Similarly, researchers have shown that the members of many technical occupations routinely view their formal education as only marginally related to the work they actually perform on the job (Bailyn 1980; Zussman 1985; Orr 1990; Bechky and Barley 1992; Nelsen and Barley 1992). If such claims are even partially accurate, simply requiring more education will do little to combat skill shortages; workers who possess unnecessary knowledge are no better equipped to perform technical tasks than those who lack additional formal education.

Proponents of job redesign, in contrast, argue that instead of attempting to bolster the skill levels of workers, one can presumably encode complex technical tasks into machines, thereby simplifying or "deskilling" jobs which can then be allocated to unskilled, poorly educated workers. However, deskilling by automation may be impossible or impractical in some instances. Typically, only a job's simple and routine technical tasks can be programmed in computer code, leaving intact its more complex tasks. While these tasks may be passed to workers in other occupations, the skills have merely been displaced, not eliminated (Braverman 1974; Smith 1987). Thus, those who seek solutions in job redesign may only serve to shift skill shortages from one occupation to another (Barley 1988). Ironically, both the educational reformers and job redesigners may actually exacerbate the very problem they aim to remedy.

The foregoing epistemological and pragmatic criticisms of the skill-as-input and skill-as-artifact perspectives ultimately stem from a single weakness: namely, that focusing on the inputs and outcomes of a labor process obscures, if not altogether ignores, the process itself. Put simply, both perspectives give little precious attention to the actual practices and processes by which work is accomplished. The importance of this oversight cannot be overstated. Since the term "skill" connotes practical competence—the "*ability to do something well*" (Attewell 1990)—an accurate definition must encompass what people do and the meanings of skill that emerge from the actual doing of work. I am suggesting that the skill-as-input and skill-as-artifact perspectives be complemented by considerations of skill-in-practice. A practice-based definition would view skill not as an entity but as a process whose substance is largely encoded in the day-to-day articulation of workers' shared understandings about what constitutes "good practice."

Such an approach to skill would enable us to avoid many of the pitfalls of reification. First, a practice-based approach would acknowledge that the meaning of skill is highly contextual, and thus will vary from job to job and worksite to worksite (Rogoff and Lave 1984; Scribner 1984). In addition, it would account for the fact that skill is exercised in a social context, and thus should be considered as much a social phenomenon as an individual attribute (Brown and Duguid 1990). Finally, in viewing skill's meanings as fundamentally contingent on the context of a job, it would draw researchers' attention to the specific competencies and abilities that a type of work actually requires. As an example of how a practice-oriented approach to skill might shed light on the nature of skill shortages and lead to more effective policy, consider the case of recent attempts to address the growing demand for medical technicians and technologists.

II. Medical Laboratory Technical Work

The development of medical technology in hospital labs accompanied the rise of clinical pathology as a distinct specialty within medicine. Pathologists are physicians (MDs) who analyze human body fluids and tissues in an effort to diagnose illness and disease. Before pathologists can make interpretations, however, considerable legwork must take place. First, specimens of patients' tissues, blood, urine, or stool must be collected. Surgeons collect human tissue samples during the course of operations, which are often undertaken specifically to secure biopsies of abnormal tissue. Nurses and phlebotemists, at the request of attending physicians, collect most other specimens, which they then route to the hospital lab.

Once specimens arrive at the lab, they must be "processed" into a form that pathologists and other physicians can use to make diagnoses. There are several ways in which specimens may be processed. In some cases, specimens are fixed to microscope slides for viewing. In other cases, specimens are mixed with reagents and subsequently tested for reactions that indicate the presence of antibodies or other signs of illness. Specimens may also be analyzed to count levels of their various constituents, as in a blood count. Processing ultimately results in the production of either a microscope slide or a test value (a number or a positive or negative result) that pathologists interpret. Historically, the occupation of medical technology emerged in response to a need for lab workers to make slides and to generate test results. Positions in medical technology are occupied by people in two groups: two-year degreed medical laboratory technicians (MLTs) and four-year degreed medical technologists (MTs).

"Lab techs"[1] may work in one of several specialties, which correspond to distinct areas or "rooms" of a lab: (1) chemistry; (2) hematology; (3) microbiology; (4) cytologic technology; and (5) histologic technology. Technicians in laboratory chemistry utilize computerized analyzers to study the chemical constituents of blood and other body fluids and to detect the presence or absence of various substances. In addition to these routine analyses, chemistry techs run various other tests including drug tests, toxicology studies, cancer marker studies, blood gas analysis, thyroid studies, and enzyme- and radioimmunoassays. Hematology involves the study of blood; the most prevalent analysis is the complete blood count (CBC), which assesses the number and morphology of different types of blood cells. Hematology technicians use sophisticated electronic blood analyzers to run CBCs, although the counts may also be done manually. Also, Hematology often doubles as a clearinghouse for a number of related tests, including coagulation studies (tests of clotting time and the presence or absence of various clotting factors in the blood), serology (pregnancy tests, rapid plasma reaction tests, anti-nuclear antibodies, tests for mononucleosis), and urinalysis. Technicians working in microbiology utilize automated equipment to carry out a number of different procedures that isolate and profile various organisms living in body solids. The pap smear is the stock and trade of cytology technicians, whose work is utilized for OB-GYN diagnostics. Cytology technicians prepare slides of individual cells that pathologists typically use to diagnose cancer. Where chemistry, hematology, and cytology technicians work primarily with cells obtained from body fluids, histology technicians traffic in human and sometimes animal tissue. Histology technicians embed tissues in paraffin blocks and then cut the blocks into wafer-thin "ribbons" on microtomes. Sections from the paraffin ribbons are later fixed onto microscope slides and stained in order for the pathologists to study them. In addition, histology technicians from time to time assist pathologists during post-mortem examinations.

Although most lab procedures were traditionally done by hand, scientific and technical advances have, over time, occasioned a radical restructuring of the content of many laboratory jobs, particularly those in chemistry and hematology. Specifically, advances in digital technology have allowed computer scientists to program into machines much of the knowledge that chemistry and hematology technicians formerly employed at their microscopes. As a result, much of the work which technicians previously performed by hand is now done quickly and accurately by machines. Automation has, whether intended or not, brought with it fundamental changes in the work performed by most techs on a day-to-day basis. Technicians in highly automated labs are now as much monitors as anything else, responsible for the care and feeding of machines. Because histology and cytology technicians have been spared this fate, physicians tend to perceive them as more skilled than the technicians in chemistry and hematology, who they consider as little more than "glorified button pushers."

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[1] A note on terminology is in order here. Laboratory workers commonly use the terms *technician*, *tech*, or *medtech* interchangeably to refer to both medical laboratory technicians and medical technologists. The terms *medical laboratory technician* and *medical technologist* and their associated abbreviations *MLT* and *MT* typically are reserved for purposes of distinguishing between two- and four-year degreed workers. Throughout this essay, I shall adopt the language of the lab except where it is necessary to distinguish the more educated technicians from the less educated ones.

The education and credentials of lab techs vary from state to state, but in most cases, candidates for an MLT (two-year) degree must complete 60 credit hours of coursework in an accredited program of medical technology. Candidates for the MT (four-year) degree, by contrast, usually complete 120 credit hours, although in some states MT degrees are awarded to persons having completed 90 credit hours and one year of clinical experience. Not all techs graduate from medical technology programs. Rather, a significant number take degrees in the physical, chemical, or biological sciences. In addition to their formal education, medtechs may seek certification from the Board of Registry of the American Society for Clinical Pathologists (ASCP). ASCP registers several classes of lab workers, including medical technologists, medical laboratory technicians, cytology technicians, histologic technicians and phlebotemists (Held 1991). In order to receive board certification, techs must satisfy coursework and credit-hour requirements and must demonstrate their technical competence by passing a national certifying exam.

The vast majority of medical technicians and technologists are females. Estimates of the percentage of women in the occupation range from 80 (Franke and Sobel 1970) to 85 percent (National Conference on Education and Career Development 1968). Some have argued that salary levels are not only low but also have lagged behind increases in the cost of living because of the occupation's gender distribution. Data from a 1990 survey of laboratory personnel salaries (Castleberry, Kuby, and Nielsen 1991b) indicate that the median annual salaries for MTs range from $22,069 for entry level positions to $30,659 for the most experienced personnel. MLT salaries range from $17,680 to $24,128. Accordingly, technologists and technicians located on comparable levels of the salary hierarchy are separated by dollar amounts ranging from approximately $4,400 to $6,500 annually.

Career ladders in medical technology essentially consist of three rungs. At the bottom are the technicians and technologists, followed by laboratory section supervisors, and finally laboratory managers. In order to aspire to supervisory jobs, techs almost invariably must possess a bachelor's degree and usually must be ASCP certified. Lab managers, on the other hand, usually must have master's degrees. Thus, technicians who possess associate's degrees have little chance of being promoted to supervisory or managerial positions.

Since the mid 1960s, laboratory administrators have been aware that major social, technological, and economic changes were shifting the skills required of medical technicians and technologists. But despite substantial forewarning, educational programs designed to produce technicians and technologists have consistently failed to keep pace with the steady increase in demand for laboratory workers. A 1967 study revealed major shortages of medical laboratory personnel (National Conference on Education and Career Development 1968). In the 25 years since the 1967 study, the extent of the shortage of MTs and MLTs has, if anything, grown worse. A 1991 study conducted by the American Society for Clinical Pathologists (Castleberry, Kuby, and Nielson 1991a) revealed increasing vacancies among a national sample of 986 medical labs. The report estimated that the vacancy rate for medical technologists stood at 11.6 percent in 1990, which represented a 2.3 percent increase from comparable 1988 figures, while vacancies among medical laboratory technicians stood at 11.1 percent, a 6.5 percent increase since 1988. These rates translated to estimates of 18,950 full-time equivalent MT vacancies and 6,000 full-time equivalent MLT vacancies among the approximately 12,000 labs in the United States. Thus, it would appear that on average, every lab in the United States now seeks at least one technologist, while one-half of the nation's labs seek one technician.

III. The Response to Skill Shortages in Medical Technology

Concern over the shortage of skilled medtechs led members of Congress to propose the Clinical Laboratory Improvement Amendments (CLIA) in 1988 (Marwick 1988; Pollner 1988). CLIA seeks to improve the quality of laboratory services by bolstering educational requirements for technicians and technologists. CLIA would impose restrictions on the lab techs who perform various tests by tying educational requirements to test complexity. Under CLIA, a few simple lab tests could be performed by personnel with no qualifications. More complex "Level One" tests could only be performed by techs possessing at least a high school diploma working under the direction of a supervisor possessing either an MD or PhD. Finally, so-called "Level Two" tests—those entailing the greatest complexity and that comprise the bulk of lab tests—could be run only by techs possessing at least an MLT degree. A number of Level Two tests would be the sole purview of technologists (Pollner 1988).

Lab personnel in rural hospitals have argued that CLIA is unrealistically stringent, since they have traditionally relied on fewer well-educated technicians, many of whom possess either associate's degrees or some level of military training (Kuehn-Kelly 1991). In fact, data from a 1990 ASCP survey indicated that as many as 44 percent of rural labs could not meet CLIA's proposed standards (Cook 1991). In response to this quandary, a second bill was placed before Congress. Under HR 2405, the Rural Clinical Laboratory Personnel Shortage Act, technicians not meeting existing formal educational requirements could be credentialed to perform lab tests currently reserved for medical technologists by passing a national equivalency exam.

Considerable debate exists around the anticipated impact and the relative merits of HR 2405. The technician community has largely embraced the bill. The three major medtech associations—the American Society for Medical Technology (ASMT), the International Society for Clinical Laboratory Technology (ISCLT), and the American Medical Technologists (AMT)—each have endorsed HR 2405. Physicians, however, have withheld support, most visibly in the ASCP's refusal to voice its approval. Opponents argue that enacting HR 2405 would not only substantially reduce the value of the four-year technologist degree but that it would subvert the primary intent of CLIA—to improve laboratory quality.

The controversy surrounding CLIA and HR 2405 raises a critical question: Why would medical technicians and technologists endorse a bill designed to downgrade skill requirements and physicians favor a bill aimed at enhancing skill requirements? The sociological literature on professionalization (Abbott 1988) and the economic literature on labor costs would suggest precisely the opposite pattern of endorsements. On the surface, CLIA would seem to protect technicians' interest in upholding a skilled identity while HR 2405 would seem to address the physicians' interest in quickly settling the skill shortage. Evidence suggests that the paradox stems from the fundamentally different conceptions of skill held by technicians and physicians.

Physicians apparently base their preference for CLIA on the belief that increasing technical education will translate into improved laboratory quality. Research on the relationship between education and lab quality (Lunz, Castlebury, James, and Stahl 1988) indicates that labs which employ only board-certified medical technologists produce significantly fewer errors on proficiency tests administered by the College of American Pathology (CAP) when compared to labs that employ only non-certified technologists. However, the fact that such studies impose an unrealistic comparison undercuts their validity among technicians and technologists: rarely do labs consist exclusively of either board-certified or non-certified personnel. The more likely scenario is a mix of certified and non-certified technicians and technologists. More importantly, such studies focus exclusively on lab outcomes without mentioning the work processes by which errors are avoided.

Technicians argue that physicians are largely unaware of what they actually do on a day-to-day basis. As pathology has become increasingly specialized, it has become increasingly difficult for pathologists to stay abreast of changes in the way laboratory tests and procedures are conducted. Lab technicians are quick to point out that most physicians cannot carry out even the most routine lab procedures. While some technicians take this as a source of pride, the majority view it as an occupational liability.

In short, it is doubtful that the technicians who favor a downscaling of the credentialing process simply fail to appreciate that the bill might deskill the occupation. Instead, technicians' support for HR 2405 most likely emerges from a definition of skill different from the one held by physicians. Recent sociological research indicates that workers derive their conceptions of skill from work practice (Attewell 1990; Orr 1990; Nelsen and Barley 1992). If it is the case that technicians fail to equate skill with education and credentials, and instead focus on lab practices to identify the attributes or abilities that constitute skill, then their endorsement of HR 2405 would seem far less baffling. Instead their endorsement would merely reflect their conviction that HR 2405 is more congruent with the work technicians actually perform.

However, there have been no studies of how technicians actually define skilled practice. At best, clues to technicians' understandings of skill lie buried in the letters or opinion pages of technician journals and newsletters and thus often go unread by all but technicians themselves. Moreover, understandings of skill that technicians derive from and communicate through the actual doing of laboratory work are likely to be held tacitly (Kusterer 1978). Since technicians' definitions of skill are quite probably taken for granted, they can only be inferred from actual observations of technicians at work. It was with the intent of investigating technicians' definitions of skill in practice and their ramifications for resolving skill shortages in technical occupations that I embarked on an ethnographic study of the work of medical technicians.

IV. Data and Method

The Setting

The study occurred over a four-month period, during which I served as participant observer in the medical laboratory of Hilltop Hospital, a medium-sized hospital located in a rural area of a Northeastern state. Observations commenced late in February 1991 and ceased in January of the next year. Over the course of the study, I observed the work of Hilltop's MTs, MLTs, phlebotemists, and other allied paramedicals. The laboratory primarily serviced Hilltop's attending physicians, but also competed with independent labs for the business of physicians located in the surrounding community. The lab's technicians were assigned to one of six specialized technical areas commonly referred to as "rooms" or "sections" by hospital staff: (1) hematology; (2) chemistry; (3) microbiology; (4) histology; (5) cytology; and (6) the blood bank. In addition, the lab contained a hospital morgue consisting of a receiving and holding area and a separate room for post-mortem examinations. The lab also housed offices for its two pathologists, an office for each of the section supervisors, the laboratory manager's office, and an administrative office where test requisitions and test results were stored.

The lab's hierarchy was relatively flat and its accompanying authority divisions clear. At the bottom of the authority structure, working in support of the techs and the physicians, was a small clerical staff, responsible for the storage and retrieval of laboratory requisitions and reports. Above these clerks were the techs themselves. Section supervisors, most of whom were former bench technicians who had been promoted to managerial positions, oversaw the work of the technician in the various sections. Although the section supervisors were responsible for hiring, firing, scheduling, and monitoring the techs, they routinely performed many of the same procedures as their subordinates, a practice that rendered them virtually indistinguishable at first glance. Far greater formal control rested with the laboratory manager, who exercised considerable influence over personnel decisions, pay increases, performance evaluations, and general lab policy. Finally, the lab employed two hospital pathologists, who assisted attending physicians by interpreting test results and slides. While the formal organizational relationship between the pathologists and the lab manager was unclear, there was little doubt that the pathologists had a significant voice in decisions bearing on all aspects of laboratory procedure, from its dress codes to its technical protocols. Pathologists frequently interacted with technicians in order to exchange information about test orders and results, but rarely discussed technical procedures with the techs.

I observed at the lab three days per week for a period of four to six hours each day. Over the course of the study, I observed all shifts in order to capture any distinctions in the lab operation at different times of the day. In addition to observation, I also interviewed several of Hilltop's technicians by employing both structured and unstructured formats. Unstructured interviews took the form of spontaneous, descriptive questions sparked by the observation of a procedure, an interaction or some other occurrence in the lab. Often, these informal interviews stemmed from casual conversations with technicians and technologists held in hallways, over coffee, or in the course of the social events that techs held, including birthday parties, going-away parties, and National Lab Week celebrations. Structured interviews took the form of directed, premeditated questions that explored a line of thought, an issue, or a concept raised in earlier observations or that served as a means of testing tentative research hypotheses derived from field data. While the bulk of the interviews were conducted with technicians, I interviewed both pathologists and the lab manager on several occasions and in several contexts. Although I typically recorded both observational and interview data as jotted field notes (which I word-processed and expanded once offsite to incorporate data still fresh in memory), I occasionally taped conversations as a way of documenting the technicians' explanations of complex technical processes or of capturing particularly important insights or thoughts offered by techs.

The lab was divided physically into separate rooms where each housing technician engaged in a distinct task; as a result, my practice was to conduct observations in a single room for an extended period of time and then move on to another room and another technical specialty. This intensive "room-centered" approach enabled me to glean a more detailed understanding of the technical aspects of each type of lab work. The interactions and interrelationships among the various rooms came into sharper focus as the study progressed.

Although the technicians rarely left their assigned rooms, there were occasions when their chores took them outside the lab. Typically, this occurred when technicians were called on to assist physicians with test procedures conducted in patients' rooms or in special rooms located on patient floors. I frequently trailed technicians on their excursions from the lab. Over the course of the study, I observed (among other things) histology technicians working in the morgue and hematology technicians assisting physicians with bone marrow extractions. I also spent several hours trailing phlebotemists on their daily rounds, both because technicians perform the work of phlebotemists in smaller hospitals and because these observations afforded a look at the physical layout of the floors housing hospital patients.

Data Analysis

Data analysis for this essay followed an iterative process of field note coding, hypothesis building, and hypothesis testing. Fieldnotes were coded by isolating all portions of text in which informants talked explicitly about occupational shortages. An analysis of this data revealed relationships between the technician shortage, laboratory quality, and the operative social definitions of skill in the lab. Subsequent coding and analysis focused on isolating interactions and encounters in which technicians tacitly or explicitly revealed the criteria by which they granted skilled status to their peers. In some cases, techs explicitly articulated the attributes that weighed in their designation of skill. In other cases, these attributes presented themselves only indirectly. I identified these tacit notions of skill by examining instances when techs evaluated, through condemnation or praise, the practice of other techs and by analyzing the work practices of technicians who were regarded widely as highly skilled. The first strategy enabled an understanding of the social norms with respect to "good practice," while the second provided a means of surfacing observable manifestations of an otherwise elusive concept of skill.

V. Technicians' Skill in Context

At Hilltop, the multiple definitions of skill are derived from and transmitted through the actual performance of laboratory work. As such, they differed substantially from the pathologists' views about the attributes that constitute a good technician and the factors that contribute to laboratory quality. While the pathologists believed that the technicians' ability to produce accurate results derived primarily from their formal education, the technicians themselves defined skill in terms of several complementary criteria for establishing what "good practice" was. Furthermore, although the pathologists imposed a universal definition of skill on all facets of lab work, the technicians' notions of skill differed from section to section and context to context. At Hilltop, three major work practices anchored the technicians' understandings of skill: (1) the mastery of machines; (2) the development of artisanal and improvisational techniques; and (3) the pooling of individual competencies in the service of interpreting ambiguous results.

Skill and the Mastery of Machines

As noted previously, electronic analyzers now dominate much of the work in a medical laboratory. Hilltop proved to be no exception. In fact, both the work and social fabric of several of the rooms—particularly chemistry, hematology, and microbiology—revolved around machines, which the chief pathologist referred to as "our workhorses." While histology and cytology had for the most part been spared the rattle and hum of machines, the technicians in other sections at times interacted exclusively with machines. In a very real sense, the machines in the chemistry, hematology, and microbiology sections of the lab controlled what, when, and how Hilltop's technicians performed their work. Indeed, to observe the work of hematology, chemistry, or microbiology techs was to observe people responding to and acting on the signs and signals that the machines emitted. When an analyzer "kicked out an abnormal value," techs would enact a well-worn routine for verifying the result. In chemistry, flashing lights and alarms on a pneumatic tube would signal the arrival of a priority specimen from the emergency room. In such instances, very little—if any—discussion occurred among the technicians; extensive protocols were in place to guide their action.

In the context of such automation, ascribing status was intimately linked to the technicians' ability to demonstrate control or mastery over their machines. Older techs in the lab attempted to assert their superiority by myth-making. They lamented the passing of foregone days when chemistry screens and blood counts were done manually and had fashioned an often retold repertoire of stories about "the old days." These stories were in the grand tradition of the legend of John Henry; they pitted the technicians' ability to do manual blood counts and chemistry screens against the machines. Needless to say, in each story the technician always outperformed the machine. However, the older techs' mythology failed to resonate with the younger technicians, most of whom had cut their teeth on electronic testing and thus took it for granted.

Instead of myth-making, most technicians had fashioned alternative and more pragmatic routes to establishing control over their machines. The techs sought to demonstrate this

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mastery by developing an ability to troubleshoot malfunctions and by maintaining a body of esoteric knowledge about the inner workings of machines.

Troubleshooting and Technical Know-How

Although the techs regularly calibrated and maintained the lab's analyzers, they occasionally malfunctioned. Given that the speedy delivery of test results depended on the proper functioning of the machines, breakdowns were viewed as no small matter by the technicians. Because physicians require laboratory services around the clock, and because manual procedures existed for the vast majority of lab tests and procedures, technicians' work did not stop for machine breakdowns. However, breakdowns did create unmanageable workloads for the techs not only because manual procedures were far slower than automated ones, but also because malfunctions required that test requisitions and results, which are normally transmitted automatically, had to be posted by hand. In addition, breakdowns elevated the technicians' anxieties because they believed that malfunctions increased the probability of reporting incorrect results. Although procedures for detecting abnormal machine values were in place, incorrect results occasionally managed to slip through the cracks, resulting in either verbal or written reprimands of technicians.

Because technical malfunctions had such dramatic implications for the work of the techs, skilled status was bestowed upon those techs who possessed the ability to troubleshoot breakdowns. The case of Tom, an MLT in hematology, illustrates this point. Tom was revered by his colleagues for his ability to troubleshoot hematology's analyzers with uncanny speed and accuracy. His troubleshooting skill on the Coulter electronic blood counter, the machine around which the work of hematology technicians focused, was particularly well-developed. Interestingly, Tom had developed his technical acumen largely on his own and without the aid of technical manuals. In fact, the error codes that the machines emitted during breakdowns had little meaning to Tom, despite the fact that the codes were explained in technical manuals:

> Tom went on to explain that the Coulter manual has a section detailing the various error codes and what they mean. However, he was unable to find this information in the manual lying atop the machine. He said he rarely uses the manuals anyway, relying instead on "my own material," which turned out to be a worn, thick red binder in which he has accumulated hundreds of technical documents, jotted notes and observations pertaining to all aspects of laboratory machine operation. He said it has taken him several years to collect these documents, beginning with his college days and continuing to the present.

Tom valued his red book greatly: he kept it locked away in a private drawer. However, he was quick to share his knowledge with other technicians when breakdowns occurred. Tom's troubleshooting ability had clearly enhanced his standing among hematology's techs, who often called on him when their machines malfunctioned. Recognition of his ability extended even to the pathologists, who had given Tom the unheard of task of programming the lab's coagulation analyzer within the operating parameters they had established.

Improvisation and Artistry in Histology

As mentioned previously, not all techs interacted with machines as extensively as the chemistry and hematology technicians. In particular, electronic analyzers were almost completely absent from the histology and cytology sections. Instead, the histology technicians worked with microtomes, instruments designed for cutting wafer-thin cross sections of tissue for microscopic examination. Unlike the analyzers in hematology and chemistry, microtomes are operated manually. Because microtomes are extremely difficult to operate, they provided the focus for histology technicians' definitions of skill.

The chief task of a histology technician was to make slides from tissue samples. Considerable work was involved in cutting whole sections of tissue, which often weigh several pounds, down to sheer ribbons of tissue that are only millimicrons thick. The first step in making slides was to embed small bits of a tissue sample into paraffin blocks. The techs in histology viewed "embedding" as the first critical juncture in tissue processing, for it required that they precisely position the tissue in the paraffin in order to maximize the potential for a cut that would yield a representative cross-section of cells. In order to accomplish this, technicians had developed a practice of embedding the tissues "flat side down." However, the techs pointed out that it often was difficult to determine which side of a sample was the "flat side." In addition, most of the techs could think of cases for which they would suspend the rule of "flat side down." Ultimately, the histology techs believed that until they actually cut a sample on a microtome, it was impossible to gauge whether they had embedded it correctly.

Cutting involved a delicate interplay between the microtome's components and the technician's movements aimed at producing a long, wafer-thin cross-section of tissue, which the technicians called a "ribbon." The microtome essentially consisted of two major parts: one which moved a razor-sharp blade through a vertical cutting path (as in a guillotine) and another which moved the paraffin block toward the moving blade. A technician would control the movement of both the blade and paraffin block by rotating two handles on the sides of the microtome in a clockwise fashion. When the paraffin block reached the blade, the movement of the blade through the paraffin created an unbroken ribbon of tissue, which the technician guided away from the microtome with the aid of tweezers. Because ribbons were extremely thin, they were susceptible to static electricity, slight air currents in the room, and even the smallest of unintended movements from the tech—all of which could instantaneously reduce a sample to a useless jumble.

If the ribbon survived, the tech removed it from the microtome and floated it in a small bath of water, where it could be captured more easily on a glass slide. Ribbons were frequently lost at this point for two reasons. First, a technician might inadvertently drop or twist the ribbon when moving it from the microtome to the water bath (which was positioned directly beside the microtome). Secondly, if the tech failed to float the ribbon with a swift, precise motion, it would break apart on the water, and the block would have to be re-cut.

The technician's final bit of artistry was to select one of the cross-sections of tissue floating on the water for fixing to a slide. Technicians captured their chosen sections by positioning a slide under the section and then quickly lifting the slide to meet the tissue which, upon contact, would adhere to the glass. The potential for tissue distortion was great at this stage of the process. If the technician failed to select a section quickly, the ribbon would dissolve in the water. In addition, if the tech did not lift the slide swiftly and precisely in the water, the ribbon would break or mangle. Histology technicians uniformly agreed that determining which cross-sections would make the "best" slide was at best difficult and that criteria varied from tech to tech. Technicians' differing conceptions of aesthetics had much to do with the decision. According to Peter, Hilltop's histology supervisor, some techs favored representativeness—a section which would provide the "best picture" of the entire tissue—while others sought the section, whether representative or not, that evidenced the least "distortion" of the original tissue.

Because slide-making was not amenable to standardized routines for controlling deviations, histology technicians believed that their ability to produce quality slides stemmed from a confluence of favorable and serendipitous circumstances. Yet despite their belief in luck, each technician had developed his or her own methods for controlling errors and improving the chances of making a "good cut." Peter was particularly proud of the technique he had developed for keeping paraffin ribbons intact as they were pulled from the blade of the microtome. He found that by blowing on the ribbon with a constant and very light stream of breath, he was able to minimize the ribbon's tendency to twist or otherwise distort. Each technician frequently improvised techniques on the spot in order to counter the unpredictable behavior of paraffin ribbons. At times, technicians improvised by subtly adjusting the speed of cutting, while at other times, they modified the technique of pulling the ribbons from the instrument or floating them on the water bath.

Given the difficulty of cutting blocks, it is not surprising that histology technicians had developed unique and ritualistic work practices which, in some cases, bordered on superstition. For example, Theresa, an MLT, preferred to set the room's radio to album-oriented rock when she cut, while Peter had little tolerance for anything other than classical music when he used the microtome. Rock and roll distracted him while classical lulled her to sleep; in both cases, the potential for disastrous results was great. Similarly, each technician laid claim to a particular microtome and a particular set of utensils, including tweezers and cleaning brushes, without which they preferred not to cut. The techs refused to share microtomes, utensils, or even workspace. I encountered this norm rather abruptly, when on the first day of observation in histology, Peter announced, "Whatever you do, don't touch Theresa's microtome..." She finished his thought: "...or I'll kick your a—." As if to concretize their feelings of ownership, the technicians had adorned their microtomes with racing stickers, photos, cartoons, and various other identifying markers. When the delicate balance of ownership was disturbed, the techs became unsettled, a point illustrated by an occasion when Peter temporarily misplaced his favorite cleaning brush. Despite having several others on hand, he spent the better part of 20 minutes searching for it before returning to the task of block-cutting.

In the context of histology, skill and artistry became virtually synonymous. The histology technicians treated their microtomes with virtually the same reverence that a guitarist might afford to a vintage Martin. Indeed, techs viewed respect for their instruments as an essential part of the constellation of factors that constitute "good practice." According to Peter, histology technicians have to cut a finger on a microtome "at least once, in order to respect the microtome" and before they can be considered adept at operating the instrument. Just as guitarists develop callouses on their fingers, skilled histology technicians wear their battle scars proudly. In addition to this appreciation for the subtleties of the tools of their trade, the histology technicians seemed to take exceptional pride in the mix of artisanal and technical skill they brought to their work. Histology technicians' attempts to construct their work as craft-like at times became almost embarrassingly exuberant, as illustrated by the remarks of an MT in a practitioner's journal:

> A histology professional is a special breed—a unique and talented artist who can take scraps of raw tissue and skillfully and efficiently transform them into small, artistic masterpieces in a few hours. Using a combination of science, art, and mechanics—a conglomerate of scientific knowledge, creative ability, and sophisticated instruments—they make the invisible become visible (Knight 1991).

Teamwork and the Role of Pooled Competency

A final aspect of skill important to Hilltop's technicians was what they called "teamwork": the ability to work in concert to produce error-free results. At Hilltop, neither MTs nor MLTs, whether certified or not, had difficulty producing accurate results for most samples. Most cases required that technicians simply verify normal results without consulting one another. Ambiguities, which were the exception rather than the rule, took the form of specimens with characteristics that the techs found difficult to identify or test results that were outside of the range of "normal values." It was in either of these instances that collaboration among technicians became critically important.

Ambiguities were problematic because they increased the chances that technicians would report incorrect results. While the technicians usually traced incorrect results to bad samples, machine malfunctions, and inaccurate requisitions, they believed that physicians were inclined to "blame" technicians for "making mistakes." Thus, the techs rarely felt that the written or verbal reprimands they received were justified, and they felt disgraced and angered by them. In addition to the ramifications mistakes had for technicians, incorrect results also had serious implications for patients, whose care often hinged on the information their physicians received from the lab. For these reasons, Hilltop's technicians were highly motivated to keep errors to a minimum.

Of the lab's activities, ambiguities were common in "differentials," the manual blood counting technique performed by hematology technicians. For manual differentials, technicians used microscopes to identify, classify, and count blood cells of different types and in different stages of development. Since the number of potential classifications was vast, technicians from time to time had to make judgement calls. When a judgement call was warranted, technicians routinely checked their interpretations by seeking the advice of one or more peers. In this way, technicians pooled their individual competencies to negotiate a collective agreement about the correct way to report ambiguous results.

I observed this process of competency pooling during virtually every day of the study. In the following excerpt from my fieldnotes, technicians collaborated to confirm an exceptional test result and to uncover a potential mistake made the previous day:

> Arlene, one of the techs from the blood bank who happened to be covering in hemo for today, was doing a manual blood count on a specimen. Upon finding a vastly elevated count of a particular kind of abnormal cells known as "atypical lymphs," she began to question the other techs sitting at the table as to what they knew about the patient. [I noted to myself that there is nothing built into the procedure of doing a manual blood count to tell the techs that an abnormal number had been counted—no flag, sign, or symbol appears as with the machine.] The subsequent discussion among the techs revealed that this was indeed an exceptionally high count. Karen, an MT, joined the discussion by noting that she had performed a Monospot test on this patient the previous day, and that the result had been negative. In fact, she said, she ran it twice. The other techs were incredulous when they heard this. Apparently, the levels of atypical lymphs they observed in this specimen go hand-in-hand with *positive* Monospot results. As a result of this discussion, the tech who had run the Monospot the day before decided it was in everyone's best interest to run it again. After all, they were on the verge of reporting two inconsistent results, and someone was sure to question it. Subsequent to this, the Monospot was rerun; the result was again negative. Despite the persistence of the inconsistency, the techs reached a consensus to release both the Monospot and the blood count results into the patient's file, having agreed that they had taken reasonable steps to ensure the accuracy of the information.

Because errors had serious implications for the techs, solid norms had developed around the practice of competency pooling in ambiguous cases, as the following excerpt from an interview with a hematology tech demonstrates. The technicians explicitly invoked these norms when one of their peers violated them:

> Karen and I got on the subject of error in the lab. She told me that the "off-hours" error described above, the one which had resulted in a red-inked reprimand from the chief pathologist, had been traced to Emily. She said that whenever such errors occur, techs go "scrambling through the records to find out who ran the test.

because you want to make sure it wasn't you." According to Karen, the case at hand involved the failure to identify cells in a spinal fluid that were clearly abnormal. In response to this error, Karen had retrieved the original sample and had shown it to some techs on the 3rd shift. Eventually it ended up on the main table in hematology, where techs on all shifts had taken turns inspecting it. Apparently, this upset Emily tremendously; she felt that Karen was making her "look bad." But Karen expressed no remorse for her actions, noting that "people get really embarrassed if they don't know something—they don't like to admit that they don't know what something is—but to me, that's nothing to be ashamed of. The mistake is in not having something reviewed (by other techs or a pathologist) if you're not sure what it is."

From this instance, it becomes clear that technicians had adopted an informal practice of public humiliation in order to impart and reinforce the importance of teamwork in negotiating the interpretation of ambiguous test results. Lab supervisors also recognized the importance of teamwork and utilized it as a criteria for evaluating technicians. For example, Jack, the chemistry supervisor, when asked about the qualities he seeks in new recruits, said that a tech's formal education and credentials were less important than "an ability to learn and a willingness to say to someone else, 'I don't know what something is.' "

Interestingly, the existing lab certification process belies the importance of teamwork and consensual sense-making for delivering accurate results. Hilltop, like most labs, was certified by the College of American Pathology (CAP), an arm of the American Medical Association (AMA). CAP assesses laboratory quality and grants certification to labs on the basis of the proficiency tests they administer. CAP periodically provided Hilltop's lab with test samples; if the technicians returned erroneous results, the lab could be decertified. But CAP samples did not enter Hilltop's lab blindly. The technicians were fully aware of when they were testing CAP samples. When confusion ensued over CAP test results, the rules of competency pooling were perhaps even more stringently enforced. During the course of the study, it was common to observe technicians double- and triple-checking CAP sample results. In these instances, a different tech performed each trial. Since CAP tests, like most other procedures in the lab, were subject to competency pooling, it would be meaningless, if not altogether impossible, to link their outcomes to the work of a single technician.

VI. Conclusion

Routine laboratory practice at Hilltop challenges definitions of skill that focus on the inputs and outcomes of work at the expense of work processes and that equate skill with formal education, credentialing, and job design. There was no evidence that skill-as-input or skill-as-artifact formulations resonated with the technicians' estimations of themselves. When granting skilled status to their peers, technicians at Hilltop showed no inclination to equate skill with formal education. In fact, there appeared to be little, if any relation between educational levels and the distribution of skilled-status among technicians; roughly equal numbers of MLTs and MTs were considered highly skilled in Hilltop's local culture.

Both technicians and technologists insisted that the extra 60 credit hours of coursework required for the MT degree resulted only in the acquisition of fairly esoteric knowledge rarely utilized on the job. In the words of one board-certified MT, "an MLT learns the same things an MT learns in school, only in a compressed fashion. We (MTs) have to go into great depth about things we don't really need to know to do medtech work." His conviction was supported by a board-certified MT in hematology, who asserted that she had learned more in her first year of lab experience than in the entire course of her education. Similarly, the majority of Hilltop's technicians downplayed the significance of board certification. While they agreed that certification served as a ticket to "a little more money" and potential advancement into a managerial position, most techs believed that board certification was unrelated to a person's ability to actually practice laboratory work.

My months of observation at Hilltop's lab revealed negligible differences in the day-to-day practice of MLTs and MTs working in the various technical rooms. Even after a considerable orientation to lab work, one would be hard pressed to distinguish technicians from technologists solely on the basis of the work they performed. When asked about the different tasks performed by MTs and MLTs in histology, Peter said simply, "In here, everyone does everything. If we see something that needs doing, we just do it. As section supervisor, that's my major expectation of the people in here."

The criteria that Hilltop's technicians utilized to attribute skilled status differed considerably from what the "skill-as-input" and "skill-as-artifact" perspectives might predict. The technicians' notions of skill were based not on education or job design but instead on specific work practices: (1) the ability to troubleshoot machines; (2) the demonstration of artisanal and improvisational panache; and (3) the social pooling of knowledge and experience in order to interpret ambiguous results.

These contextually embedded notions of skill have important implications for laboratory work. By engaging in these practices, technicians were more likely to turn out correct results, and hence to protect patients from the potentially disastrous consequences of lab errors. Because these practices were intimately linked to laboratory quality, the techs had deemed them an important part of the characteristics that distinguish "good labs" from "bad labs." However, these skills were acquired, transmitted, and exercised not in the classroom, but in the dynamics of everyday lab practice. Put simply, technicians gleaned a substantial and important body of practical knowledge on the job. Recognizing this fact may very well be the key to combating the personnel shortages that have long plagued hospital laboratories.

More generally, if core competencies required for technical work are largely acquired on the job, reformers might do better to think of technical occupations as "new crafts" (Barley 1991), in which practical, working knowledge comprises the foundation of workers' skill. This is not to say that technical workers do not require formal knowledge or that such knowledge should not be transmitted in educational settings. Even crafts such as carpentry and machining require some basic knowledge of math and science. However, the formal knowledge base of technical occupations, while certainly larger than the base required of craftswork, may be less substantial than previously thought.

If reformers were to modify technical education in light of a craft-based model of technical work by relaxing the standards by which technicians are credentialed, technical occupations could begin to attract high school students with an interest in math and science who currently are being funnelled into service sector jobs that require only high school diplomas. If practical, working knowledge is as central to technical work as this study of lab work has suggested, then a compelling argument exists to short-circuit the current lengthy path to a technical career in favor of an apprentice-based educational program which values practical experience as highly as formal knowledge (Hamilton 1990).

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