The Uses of Useful Knowledge

Science, Technology, and Social Boundaries in an Industrializing City

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IN 1824, IN PHILADELPHIA, PENNSYLVANIA, the newly formed Franklin Institute for the Promotion of Science and the Useful Arts held its first annual Exhibition of Manufactures. The managers awarded premiums for the most admirable objects on display and commended many others. At this and subsequent annual exhibitions, silver medals were awarded for products ranging from white lead to red earthenware, from iron ore made only with anthracite coal to silk spun only in Pennsylvania. At the first exhibition, the Pennsylvania Institution for the Deaf and Dumb was awarded two separate silver medals: one for a specimen of coarse cotton fabric, and one for a braided grass bonnet. The grass bonnet made by a Mrs. Hopkins of Lancaster and the split straw hats produced in two other Philadelphia schools were also commended. Thus the "perfection of workmanship" the managers sought to encourage was of many different types, and some of the "workmen" were women or even — as the managers phrased it in reference to residents of the Roman Catholic Orphan Asylum — "infant artizans."[1]

At first glance, "science and the useful arts" might appear to parallel the familiar late twentieth-century phrase "science and technology." Yet the range of products and processes included under the nineteenth-century rubric of "useful knowledge" — needlework as well as metalwork, spinning as well as mining — contrasts sharply with the late twentieth-century connotations of the term "technology." Although the Franklin Institute's carefully assembled "cabinet" of minerals bears little resemblance to modern laboratories and instruments, the cabinets and collections of nineteenth-century science are familiar to readers of *Osiris.* Straw bonnet making, on the other hand — a manufacture to which the Franklin Institute managers devoted substantial attention in their 1825 annual report — may seem to many readers a more surprising inclusion under the rubric of "technology."

This article has two tasks. First, as a historian of technology among scholars studying science, I find I add yet another dimension to an already interdisciplinary conversation. Before I can describe my own research and its bearing on "women, gender, and science," some background on approaches to "women, gender, and technology" is in order. Second, I turn to my own historical work on urban

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[1] "Report of Exhibition," *First Annual Report of the Franklin Institute* (1825), pp. 65–66, 86–88; and *Franklin Journal and American Mechanics' Magazine,* 1826, *1*:2-5, 1826, *2*:264.

industrialization and social boundaries. This study focuses on technical education, in which knowledge commonly labeled both "scientific" and "technological" is transmitted to children. Making comparisons within and among institutions offering such technical education raises questions not only of access to and ideas about various kinds of technological knowledge, but also about the role of science as a badge of white, male, middle-class identity, a badge of—in the language of the introduction to this volume of *Osiris*—both social and cognitive authority. This article explores programs offered in a single city in two periods: in the 1820s, when Philadelphia institutions from the Franklin Institute to the House of Refuge for juvenile delinquents sought new ways of preparing youths for productive adulthood in the early industrial city; and in the 1880s, by which time professional educators in the city's public schools had taken the task as their own. A brief tour of Philadelphia at midcentury highlights themes and provides transition between the two discussions.

WOMEN, GENDER, TECHNOLOGY, AND SCIENCE

Unlike women scientists, women technologists are ubiquitous. Scholars studying women, gender, and technology have long since pointed out that the task of writing a more complete history of technology begins simply with taking seriously the broad emphasis on "making and doing" set forth in the early postwar explorations of the field.[2] "Making and doing things" readily includes straw bonnet making; it includes both women's work and artisanal manufactures; it includes the tools of the Stone Age and the machines of the Space Age. By scholarly rather than popular definition, then, technology is not limited to a study of men, of machinery, or of Western cultures. On the contrary, if technology in the modern West has come to be defined as

[2] For an introductory tour of work on women, gender, and technology see Ruth Schwartz Cowan, "The 'Industrial Revolution' in the Home: Household Technology and Social Change in the Twentieth Century,'. *Technology and Culture,* 1976, *17*:1-24: Cowan, "From Virginia Dare to Virginia Slims: Women and Technology in American Life," *ibid.,* 1979, *20*:51-63: Joan Rothschild, ed., *Machina* ex *Dea: Feminist Perspectives on Technology* (New York: Pergamon, 1983): Judith McGaw, "Women and the History of American Technology," *Signs: Journal of Women in Culture and Society,* 1982, *7*:47-77: McGaw, "No Passive Victims, No Separate Spheres: A Feminist Perspective on Technology's History," in *In Context: History and the History of Technology;* ed. Stephen Cutcliffe and Robert Post (Bethlehem, Pa.: Lehigh Univ. Press, 1989), pp. 172–191; Judith Wajcman, *Feminism Confronts Technology* (State College: Pennsylvania State Univ. Press, 1991); and Cynthia Cockburn and Susan Ormrod, *Gender and Technology in the Making* (London: Sage, 1993). For more recent historical work and a bibliographical essay see Nina Lerman, Arwen Mohun, and Ruth Oldenziel, eds., *Gender and Technology, Technol. Cult.* (special issue), 1997, *38*(1)(hereafter cited as *Lerman et al., eds., Gender and Technology).* For a survey of similar arguments in archaeology see Alison Wylie's essay in this volume.

In the first volume of *Technology and Culture* (1959). Mel Kranzberg defined "technology" as "how things are commonly done or made" and "what things are done and made": see Melvin Kranzberg, "At the Start," *Technol. Cult.,* 1959, *1*:1–10, on pp. 8-9. He was building on the work of Charles Singer and others. Brooke Hindle used the phrase "means of making and doing things" in his essay "The Exhilaration of Early American Technology" (1966), rpt. *Early American Technology: Making and Doing Things from the Colonial Era to 1850,* ed. McGaw (Chapel Hill: Univ. North Carolina Press, 1994), pp. 40-67. For a more recent discussion and a range of scholarship see the introduction and essays in McGaw's volume and Lerman *et al,* eds., *Gender and Technology.* Finally, it is important to note that according to this definition "engineering" is *part of* but not *synonymous with* "technology."

a masculine pursuit, then that association itself must become an object of study rather than an initial premise.[3]

Engineering offers ready parallels to science. Engineering, however, is only a small (albeit important) part of human technological activity. While the study of women in professional engineering closely parallels the study of women as professional scientists, the study of women constructing and repairing clothing or processing raw materials into a family dinner, like the study of carpentry and iron puddling, raises somewhat different questions.[4] In addition to the issue of how women fared in a male domain, the fundamental questions are about how gender boundaries have been drawn and redrawn across a truly enormous terrain. The examination of relationships between gender and knowledge becomes even more complex with the inclusion of technological knowledge, for by most accounts sewing and carpentry demand a different kind of knowledge than biology and physics. In addition, the knowledge involved in sewing and carpentry is, if anything, more embedded in its particular social context than is the fairly elite work of science. Indeed, many who study gender and technology are convinced that a full understanding of either gender or technology in the modern West demands analysis of the reciprocal relationships between them. Such relationships remain underexplored.[5]

[3] Compare the feminist broadening of "medicine" into "healing" as a means to consider women's activities and gender boundaries. For the importance of masculinity in studies of technology see Ruth Oldenziel, "Gender and the Meanings of Technology: Engineering in the U.S., 1880–1945" (Ph.D. diss., Yale Univ., 1992); Carroll Pursell, "Masculinity and the History of Technology," *Polhem,* 1993, *11*:206-219; McGaw, "No Passive Victims, No Separate Spheres"; and the bibliographic essay in Lerman *et al.,* eds., *Gender and Technology.* On European views of technology and other cultures see Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, N.Y.: Cornell Univ. Press, 1989).

[4] Nineteenth-century educators recognized the latter comparisons clearly enough when they discussed school needlework in committees on "industrial arts." More recently, scholars studying technology and gender, recognizing that preparing food and making clothing have been labeled activities of consumption (or reproduction) rather than production and manufacture, have called for more detailed study of all aspects of what Ruth Schwartz Cowan has called "the consumption junction." See Ruth Schwartz Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in *The Social Construction of Technological Systems,* ed. Wiebe Bijker, Thomas P. Hughes, and Trevor Pinch (Cambridge, Mass.: MIT Press, 1987); see also the bibliographic essay and articles in Lerman *et al.,* eds., *Gender and Technology.* Manual training and industrial arts for girls and boys are discussed later in this essay.

[5] See Lerman *et al.,* eds., *Gender and Technology. A* feminist philosophy of technology has, as far as I know, yet to be developed — as does a sophisticated epistemology of sewing or carpentry. In my work I define the term "technological knowledge" broadly, so it includes both "skill" and "technical expertise." Following cognitive scientists such as Howard Gardner, I assume that technological knowledge involves a range of cognitive activities — what Gardner calls "intelligences." See the introduction to Howard Gardner, *Frames of Mind: The Theory of Multiple Intelligences* (New York: Basic, 1985). See also the introduction to Nina Lerman, "From 'Useful Knowledge' to 'Habits of Industry': Gender, Race, and Class in Nineteenth-Century Technical Education" (Ph.D. diss., Univ. Pennsylvania, 1993). This definition of technological knowledge includes the knowledge of users as well as that of designers. Technological knowledge has traditionally been examined in relation to scientific knowledge. Engineering knowledge, in particular, has received much attention. While there is a growing awareness of the place of "craft" in this discussion — noted as a newly emergent theme as early as 1985, in Staudenmaier's survey of the field — on the whole technological knowledge has been treated quite narrowly in the history of technology literature. See John Staudenmaier, S.J., *Technology's Storytellers: Reweaving the Human Fabric* (Cambridge, Mass.: MIT Press, 1985); Edwin Layton, "Mirror-Image Twins," *Technol. Cult.,* 1971, *12*:362-580; Layton, "Technology as Knowledge," *ibid.,* 1974, *15*:31-41; and Layton, "Through the Looking Glass, or News from Lake Mirror-Image," in *In Context,* ed. Cutcliffe and Post (cit. n. 2), pp. 29–41. See also George Wise, "Science and Technology," in *Historical Writing on American Science: Perspectives and Prospects.*

Even so, to anyone familiar with Western industrial gender systems it will hardly be surprising that in the 1820s plaiting straw to make hats was technological knowledge provided to women and girls, even when encouraged by local patricians, or that the Franklin Institute managers did not teach bonnetmaking to their sons and apprentices. The larger issue, and the one I want to address here, is about the changing meanings of terms like "science," "technology," and "useful knowledge," the changing meanings of particular kinds of useful knowledge, and the ways such meanings have interacted with social categories such as gender, race, and class (the meanings of which have also changed). As scholars studying gender have suggested, this kind of exploration demands attention to boundaries and to "others": to science versus not-science: to technology versus art, or craft, or nurture: to engineering "knowledge" versus artisanal "skill."

In this essay I will argue that, historically, theoretical and abstract approaches to making and doing things — including mathematics, science, quantification, drafting, and design — came to be treated in opposition to more specific kinds of artisanal knowledge and also to be associated with maleness, with whiteness, and with middle-class upward mobility. "Science" became a label to appropriate, as well as a knowledge to possess. Social and cognitive authority, in other words, reciprocally bolster each other. And if technologies called "scientific" have been associated with social categories connoting (and possessing) power, then ideas about technological knowledge will tell us something about the social, political, and cultural uses to which science has been put in American society.

As already suggested, I explore these questions by making comparisons between and among nineteenth-century institutions providing technical education to children. Education as a locus of study allows examination of the relationships between social structures and ideologies, on the one hand, and knowledge and ideas about that knowledge, on the other. Institutional reports provide extensive justifications for diverse types of education, as well as evidence of real programs providing access to some kind of training and credentials for real people, varying by time and place. Whether the knowledge acquired or the credential bestowed is the more valuable result, educational institutions have long existed both for what goes on inside them and for their differentiation of those who do and do not attend. Studying the education of children in a broad range of institutions provides a view of technological and scientific knowledge across boundaries of gender, race, and class.

The following discussion is drawn from a larger study of technical education in the city of Philadelphia in the nineteenth century. The present article does not pretend to a complete analysis of any one period or institution: rather, in highlighting the uses of science in technical education in different periods in the nineteenth century, it aims to sketch shifting ideas about technological knowledge, in particular about the kinds of knowledge associated with, and opposed to, science.

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ed. Sally Gregory Kohlstedt and Margaret Rossiter (Baltimore: Johns Hopkins Univ. Press, 1985). pp. 229-246. The best recent accounts also focus on engineering knowledge: see Eugene Ferguson, *Engineering in the Mind's Eye* (Cambridge, Mass.: MIT Press, 1992): and Walter Vincenti, *What Engineers Know and How They Know If: Analytical Studies from Aeronautical History* (Baltimore: Johns Hopkins Univ. Press, 1990). Several promising avenues treat shopwork: Steven Lubar, "Representation and Power," *Technol. Cult.,* 1991, *36*(Suppl.): S54-S74 (this is a revised version of "Representing Technological Knowledge" [paper presented at SHOT Critical Problems Conference, session entitled "Knowing, Thinking, and Doing," Madison, Wisconsin, 1991), and Robert Gordon, "Who Turned the Mechanical Ideal into Mechanical Reality?" *ibid.,* 1988, *29*:744-778.

"RAISED BY THEIR TALENTS": ARTISANAL KNOWLEDGE AND THE NEW MOBILITY

In the 1820s, even in a growing urban center like Philadelphia, artisanal work could still provide a path to respectable "independence": a man might not live in luxury, but he could call himself master and make his own way in the world. At the same time, however, some Philadelphians were constructing a new middle-class identity increasingly dissociated from craft work; in the industrializing city, new notions of upward mobility meant distance from workshop activities. Mobility was always possible in the young republic — especially in the eyes of those who sponsored educational and charitable institutions — but it was meted out in appropriate doses: children who might have been dependent on society could be rendered productive adults if they learned a trade; artisans might in turn become proprietors or go into business.[6] Both independence and mobility, of course, were perceived as male provinces — a woman's status was presumed to be defined by her father or husband. As a result, the rhetoric and usually the content of technical education for males and females, for middling and lower sorts, differed markedly. This section returns to the Franklin Institute and introduces the Walnut Street Charity School, run by the Philadelphia Society for the Establishment and Support of Charity Schools, and the Philadelphia House of Refuge, a reform school for juvenile delinquents.

The Act of Incorporation of the Franklin Institute for the Promotion of Science and the Useful Arts declared that its goals would be furthered "by the establishment of popular lectures on the sciences connected with them, by the formation of a cabinet of models and minerals, and a library, by offering premiums on all objects deemed worthy of encouragement, by examining all new inventions submitted to them, and by such other measures as they may judge expedient." Its members were to be drawn from "manufacturers, artizans, and persons friendly to the mechanic arts." While the managers formed the Franklin Institute at least partly on the model of mechanics' institutes such as those in New York and Glasgow, they soon developed loftier visions: in addition to the "volunteer" lectures in which members might present information of use to other members, they would establish professorships and a permanent course of lectures in each of four fields: natural philosophy, chemistry and mineralogy, architecture and civil engineering, and mechanics. Beginning in 1824, the institute sponsored the annual Exhibition of Manufactures: in 1826 it began publishing the Franklin Journal, which soon became heavily technical and scientific in its content. After some dispute with the U.S. Patent Office the institute also gained access to new patent records and disseminated news of inventions. In 1826, as well, the managers added a High School Department, for the purpose of extending to "citizens in moderate circumstances, the same advantages of education which are

[6] For extensive discussion of nineteenth-century middle-class definition see Stuart Blumin, *Emergence of the Middle Class: Social Experience in the American City, 1760–1900* (Cambridge: Cambridge Univ. Press, 1989); on business see also Patricia Cline Cohen, *A Calculating People: The Spread of Numeracy in Early America* (Chicago: Univ. Chicago Press, 1982). On artisans and proprietors see George Escol Sellers, *Engineering Reminiscences,* 1815–1840, ed. Eugene Ferguson (Washington, D.C.: Smithsonian Institution Press, 1965): Anthony Wallace, *Rockdale: The Growth of an American Village in the Industrial Revolution* (New York: Knopf, 1982); and Sean Wilentz, *Chants Democratic: New York City and the Rise of the American Working Class, 1788–1850* (Oxford: Oxford Univ. Press, 1984). For discussion of the educational and charitable community see Alan M. Zachary, "Social Thought in the Philadelphia Leadership Community, 1800–1840" (Ph.D. diss., Northwestern Univ., 1974).

now almost exclusively enjoyed by the children of the rich."[7] The Franklin Institute fashioned itself into, and remained for some years, the premier technical and scientific institution of the United States. It is worth noting that, although "ladies" were admitted to the lecture series and women submitted items for display at the annual exhibitions, most of the activity at the Franklin Institute took place in an entirely male environment.

Technical education for youth began with their admission to the lecture series planned for their elders. There were, initially, some problems with this approach: by the spring of 1827, the end of their second full season, the lectures were well attended, "but as they proceeded, much inconvenience was experienced from the indecorous conduct of a considerable number of boys, whose only object in attending must have been amusement, as many of them were wholly disinclined" to pay attention. Some of the senior members stopped coming, and over the next several years the managers issued a series of rules and restrictions. Eventually they resorted to that time-honored method of insuring students' attentiveness: the professors would quiz the youths before each lecture on the content of the previous one. "Thus," they reported, "an honourable emulation is excited among them, and instead of a place of amusement, the hall of the Institute has become to them what it should be, a place of instruction."[8]

Meanwhile, a far less problematic group had been included in the lecture audience: by late 1827 the managers had issued ladies' tickets at $2 per season. In London and Glasgow the practice had "been found to produce all the good consequences anticipated from such a measure: affording to those who are our earliest and most influential instructors, a mass of useful information, through the pleasing medium of rational amusement; whilst their presence stimulates to exertion, and tends to the promotion of order and decorum during the hours of the meeting."[9] Several notable differences from the treatment of members and boys emerge. "Amusement" was acceptable for females, but not for males; and whereas artisans would be improved *as artisans* by learning science, ladies learning science would help improve the men, by raising sons well prepared for further instruction and by promoting decorum in

[7] Franklin Institute, *First Annual Report* (1825) (cit. n. 1), pp. 7, 8: and *Address of the Committee of Instruction of the Franklin Institute of Pennsylvania, on the Subject of a High School Department to Be Attached to That Institution* [Philadelphia, March? 1826], p. 2. This text is hereafter cited as Franklin Institute, *Address* (Mar.? 1826). (There were two similarly titled addresses printed that year: the Library Company of Philadelphia catalogues them as "March?" and "September?" respectively [see also note 12, below].) The founding and development of the Franklin Institute are ably recounted in Bruce Sinclair, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824–1865* (Baltimore: Johns Hopkins Univ. Press, 1974).

[8] Members were invited to purchase tickets for their sons and apprentices at $1 each for the season: *Franklin J.,* 1826, *1*:131. Membership cost $5 per year; the drawing school cost $5 for a ten-week term of two classes each week. Tuition in the drawing school included admission to the lectures. Thus, a member wishing to send his son or apprentice to drawing school had to have $10 he could spare. Weavers, in this period, might have made $5 per week if they were lucky enough to have more than a normal week's worth of work and ambitious enough to put in extra hours. Not surprisingly, of the more than five hundred men listed on the 1825 membership list, there was only one weaver: two made shoes, four were tailors, and eighty were merchants. The preponderance were more prosperous artisans and manufacturers of the sort one might call small businessmen. See Franklin Institute. *First Annual Report* (1825): and Sinclair, *Philadelphia's Philosopher Mechanics.* On wages see Philip Scranton, *Proprietary Capitalism: The Textile Manufacture at Philadelphia,* 1800–1885 (Cambridge: Cambridge Univ. Press, 1983), pp. 123-124. For details of problems with boys in lectures see *Franklin J.,* 1828, *5:*74, 1829, *7:*76.

[9] *Franklin J.,* 1827, *4*:331.

the lecture hall. The lectures provided technical education at different levels for different groups: elevation for mechanics, instruction for youth, rational amusement for ladies.

During these early years some of the managers had concluded that lectures better suited adults than young people. Already they had established evening classes in mathematics and mechanical drawing, open to adults and youth, but these were deemed insufficient. The managers decided that only a High School Department would fill the need they saw and set about designing a course of study "such as is universally selected by the enlightened parent, whose wealth enables him to make a choice for his son."[10]

The rhetoric announcing the new school borrowed from a republican emphasis on opportunity:

> In this country, where permanent distinctions of rank are inconsistent with the spirit of our republican institutions, it is impossible to tell from the situation of the parent, what may be the destiny of the child. The system of education to be adopted, ought not, therefore, to presuppose that the pupils are to be necessarily mechanics or manufacturers, or that even if they are, their prospects in future life are to be confined within the walls of their workshops.

Accordingly, none of the courses offered was specifically vocational. The three-year curriculum included both "practical" education and preparation for college. In the view of the committee, this meant one to three years of writing, grammar, declamations, composition, rhetoric; ancient and modern geography and history, mythology, political economy, the constitutions of the United States and of Pennsylvania; arithmetic, algebra, geometry, trigonometry, surveying, mensuration; linear drawing, drawing in perspective; bookkeeping, stenography; natural philosophy, mechanics, chemistry, astronomy, natural history: and Greek, Latin, French, and Spanish. Only the best students would complete all of the offerings on schedule. Others would either take fewer courses or stay in school longer.[11]

In their high school, the managers at the Franklin Institute intended to offer opportunity at a modest price — tuition of $28 per year included "fuel," pens, ink, and slate pencils but not the required books and stationery — but such opportunity as might very well lead a boy out of his mechanic father's workshop. While the institute intended to encourage artisanal production generally, the content of its educational activities became increasingly removed from artisanal know-how. The technological knowledge offered to artisans was intended to "improve" them, but at the same time the message was clear that an improved artisan would no longer roll up his sleeves and work in a workshop. Improved artisans, including several influential members of the institute, were increasingly likely to be manufacturers, masters of an enterprise larger than a traditional shop.[12] This trend also meant that the artisanal men who worked in such shops, for wages, became increasingly unlikely to spare either

[10] Franklin Institute, *Address* (Mar.? 1826), p. 20.

[11] *Ibid.,* pp. *2* (quotation), 3-4.

[12] On the expenses covered by tuition see *Address of the Committee of Instruction of the Franklin Institute of Pennsylvania, on the Subject of a High School Department to Be Attached to That Institution* [Philadelphia, September'? 1826], pp. 5–6. See Blumin, *Emergence of the Middle Class* (cit. n. 6), for discussion of occupational titles and status. Such an "improved" manufacturer would have to know the workings of his business, but that knowledge would not have been gained in school.

cash or the earning power of their sons for the pursuit of languages and natural philosophy.

Another view of education and upward mobility is offered by the Walnut Street School, established by the Philadelphia Society for the Establishment and Support of Charity Schools (PSESCS). Begun in 1799 as the Philadelphia Society for the Instruction of Indigent Boys, the society had at first run a weekly evening school and then, two years later, a day school. By the 1810s, at least some members of the society were avid supporters of the Lancasterian or monitorial movement, in which older students helped teach younger ones (allowing one teacher to handle a hundred or more students). Originally a system designed to provide cheap education to hordes of poor children, it was often justified, in the United States, as a democratic practice: the Franklin Institute's high school used a modified version of the system. The PSESCS managers explained: "All the children of a village or neighborhood may meet together on the same footing, be disciplined by the same rules, inspired by the same emulation, influenced by the same motives, impressed with the same moral sentiments, and be fitted for life on an equality that no other system affords." By 1817 the society was providing Lancasterian education for nearly seven hundred children in several schools.[13]

The standard school subjects in both England and the United States included reading, writing, arithmetic, and, for girls, needlework. The needlework was by and large such as a girl might need to maintain a household: plain sewing, marking, and knitting were basic domestic knowledge (if also sometimes a means of livelihood when no other source of income was available). Such needlework had long been a feature of girls' schooling, although in charity schools it stopped short of the usual schoolgirl's sampler.[14] Teaching schoolgirls to make straw bonnets, however, which a number of Philadelphia schools did in the 1820s, was an innovation prompted by a different philosophy.

Bonnetmaking was introduced on the girls' side of the Walnut Street School in 1823, in addition to the reading, writing, arithmetic, and sewing already taught. Not all girls participated; it seems to have been optional, and it cut down on time in other classes. The annual report for that year explains that the managers believed that bonnetmaking "would prove useful, as it would afford the pupils an opportunity of becoming acquainted with a business, by the aid of which, they would be enabled to provide for themselves a comfortable livelihood, and, perhaps, eventually introduce among the poorer classes of our population, an additional means of support, and

[13] *Manual of the System of Teaching Reading, Writing, Arithmetic, and Needlework, in the Elementary Schools of the British and Foreign School Society,* 1st American ed. (Philadelphia: Printed for the Philadelphia Society for the Establishment and Support of Charity Schools, 1817), pp. v–xi. In the annual reports of the PSESCS from the 1820s, the managers repeatedly emphasize the humbleness and quietness of their work, which was "not such as to excite applause; for its effects, though certain and of extensive influence, are produced silently and without display": Philadelphia Society for the Establishment and Support of Charity Schools, *Annual Report* [for 1828] (hereafter cited as PSESCS, *Annual Report* [year]. At least some of the managers were members of the Society of Friends (Quakers).

[14] Details on the charity school needlework curriculum are provided by the *Manual of the System.* Samplers, embroidered with flowers and verses in silk on linen, demonstrated a girl's mastery of her needle but also indicated that her family had some time and money to spare. See Betty Ring, *"Let Virtue Be a Guide to Thee": Needlework in the Education of Rhode Island Women, 1730–1830* (Providence: Rhode Island Historical Society, 1983).

thereby, considerably diminish the public burdens."[15] The managers, who referred to "pupils" but taught bonnetmaking, like sewing, only to girls, seemed not to know that members of poor families were likely already to be working at any tasks that paid or that spare time among the women of the "poorer classes" was a rare commodity indeed.

New plans for the Boys' Department followed a different approach. The same annual report described the managers' intentions to offer boys "the higher branches of an English education." The board had already restricted admission in the boys' school to those who knew how to read, but even so the teacher was still too busy to extend the curriculum much. The board believed that in a nation "where men are raised by their talents and virtuous actions, to the highest stations, it is an object of primary importance, that every child should partake of learning." They believed it was their duty not to permit the parent's poverty to be a "barrier" to the child, and they expected that students from the school could grow up to be "respectable citizens" given the chance.[16]

These innovations — bonnetmaking on the one hand and "higher branches" on the other — suggest a certain ambivalence on the part of the managers, which they not coincidentally manifested in strongly gendered terms. On the boys' side, teaching higher branches might produce "respectable citizens"; while on the girls' side, a new knowledge "among the poorer classes" might "diminish the public burdens." That the 1820s was a time of flux and contrasts is evident in several of the era's institutions — bonnetmaking was as paradoxical (and as short lived) as the Franklin Institute's monitorial high school teaching Greek, Latin, bookkeeping, and drawing — and that the "public burdens" should be gendered female is not inconsistent with the nature of nineteenth-century charity. But evidence from these two institutions makes clear the emergence of middle-class ideas linking mobility, assumed to be a male prerogative, with education, business, and science. Mobility was also increasingly disengaged from direct participation in artisanal production. Specific artisanal skills were appropriate for some but seemed to offer restricted opportunity rather than hope that the possessors might rise to the "highest stations." This new male middle-class knowledge, however, was distinguished from its female counterpart either by the uses to which it would be put or by outright denial: when women were granted access, it was for the good of their sons; but more often their education was simply limited. In this same period, according to Patricia Cline Cohen, arguments about women's education began to declare females incapable of learning mathematics, rather than simply assuming they did not need it.[17] The same managers who wanted to offer "higher branches" to boys advocated bonnets in preference to books for girls.

If the Walnut Street managers shared rhetoric with those of the Franklin Institute when they discussed "respectable citizens," their discussions of the "poorer classes" had more in common with reports from the Philadelphia House of Refuge. At that

[15] PSESCS, *Annual Report* [for 1823], p. 7. Bonnetmaking continued for several years; then sales fell off, and by 1830 it had disappeared from the curriculum. See subsequent annual reports.

[16] *Ibid.,* pp. 5-7.

[17] See Cohen, *Calculating People* (cit. n. 6, for discussion of attitudes about females and arithmetic in the early nineteenth century. On women's education see also Linda Kerber, *Women of the Republic: Intellect and Ideology in Revolutionary America* (Chapel Hill: Univ. North Carolina Press, 1980).

institution, a "home" for "juvenile delinquents" to which boys under twenty-one years of age and girls under eighteen could be committed by law or parent, provision for learning trades (for boys) and housewifery (for girls) was made to ensure the pupils' ability to participate appropriately in life beyond the institution. The refuge housed youths who would otherwise live on the streets, in the almshouse, or in prison.

Refuge managers intended to provide an environment in which potential criminals could learn to be productive and upstanding citizens. In this context, technical education had several purposes: in addition to providing a livelihood, education and employment were fundamental to the establishment of moral rectitude. As the managers put it, "Idleness is the parent of vice. The mind no less than material nature abhors a vacuum [sic]. If not furnished with useful reflections, it will dwell upon those which are pernicious. Hence the House of Refuge will be a place of never ceasing occupation, to every inhabitant." Most of that occupation would be some form of "Manual Labor." and at the House of Refuge, unlike in prison, the inmates would acquire knowledge of a trade. They would also receive basic schooling before and after a full day of work. As soon as they were sufficiently reformed, the children would be bound out as apprentices, a traditional practice grounded in British and colonial poor law. Children committed to the House of Refuge would be under its jurisdiction until they reached majority — age eighteen for girls, twenty-one for boys — sentenced to a wholesome environment throughout their childhood.[18]

The technical education at the House of Refuge, as opposed to the reading, writing, and ciphering of the schoolroom, was not of the formal classroom type found at the Franklin Institute or the Walnut Street School. Rather, it was conducted on the traditional model of apprenticeship, in which a child acquired skills as he or she assisted with the tasks of the workshop or household. The annual report for 1829 told its readers that the boys were engaged in bookbinding, basketmaking, wickerwork, shoemaking, tailoring, and carpenters' work. The girls performed sewing, washing, ironing, mending, cooking, and general housework. By May 1830 the managers could proclaim that all the clothing worn by the pupils was made within the house.[19]

Finding the right work for the boys was tricky enough that at several points there were more boys at the House of Refuge than jobs, and then even older boys ended up with simple tasks like picking oakum. In contrast, there was no difficulty employing the girls: they did all the housework for the institution.[20] For boys, the

[18] House of Refuge, *Address to the* Citizens. . . (Philadelphia, 1826), pp. 9–12.

[19] House of Refuge, *Annual Report* [for 1829] (Philadelphia, 1830); and House of Refuge, *Annual Report* [for 1830] (Philadelphia, 1831) (these reports will be cited hereafter as House of Refuge, *Annual Report* [year]).

[20] For the older boys, when there was work the assignments were taken seriously. In several cases a boy was reassigned because he was disinclined toward a particular kind of work. See House of Refuge, Minutes of Visiting Committee (HR-A201), 10 Jan., 18 Mar., 18 Sept., 3 Nov. 1829; and House of Refuge, Superintendent's Daily Log (HR-B-1), 7 Jan., 17 Mar. 1829. These documents are at the Historical Society of Pennsylvania, Philadelphia, in the House of Refuge/Glen Mills School collection; I thank C. D. Ferrainola of the Glen Mills School, Concordville, Pennsylvania, for permission to use and quote from these materials. The managers attended to the housework only rarely, as when the Visiting Committee ordered that "the steward will request the matron to put aside all work which is not absolutely necessary, until a sufficient number of shirts can be made to satisfy each boy with two per week, and each boy with an apron": House of Refuge, Minutes of Visiting Committee (HR-A201), 21 Apr. 1929.

schoolroom hours were the ones more consistently filled. Regular schooling for the girls, however, was evidently not the highest priority: the house had been open five months before the girls' schooling was rescheduled around the demands of housework. At that point the superintendent noted an improvement — twenty-two of twenty-five resident girls attended school that day.[21] The records do not indicate how few had attended before.

Thus, ideally, the successful boy committed to the refuge would acquire a rudimentary education and workshop-based craft knowledge and go out into the world as a respectable artisan. The successful girl would get married, having acquired the knowledge needed to run her own household. Of course, the refuge girls were also prepared to work in other people's households. The process of making dependent boys independent included, by definition, basic schoolroom education. Lower-class girls, never expected to achieve early nineteenth-century "independence" anyway, could make do without schooling if housework intervened.

Comparing the lots of the boys in the various institutions, we can see a hierarchy of technological knowledge assigned according to social hierarchies: artisanal knowledge might make better citizens of the poorest classes, but artisans themselves should learn scientific theory, mechanical drawing, and business techniques if they wanted to improve themselves. For girls, the ubiquitous emphasis on the indispensable tasks of housewifery masks a set of distinctions based on presumed family status — without the rhetoric of mobility. Science might well be appropriate "rational amusement" for those women whose sons or husbands needed science. Craft knowledge such as bonnetmaking would better fill the ostensible leisure time of poorer women. Although the respectable artisan still had his place in the social and technological hierarchies of the 1820s, as he did in the manufacturing enterprises of the urban economy, already science was becoming "useful knowledge" not only for its application to manufactures, but also as a badge of distinction for the emerging middle class and for a new kind of middle-class manhood in a new industrial order.

"TRAINED TO BUSINESS": SCIENCE, DOMESTICITY, AND MANUAL LABOR

By midcentury, amidst the tumult of a rapidly growing city, the social and technological order had in many ways stabilized. The shift from artisanal toward industrial production was reflected in an emphasis on "habits of industry" and a new respectability of wage work as a means, for men, of making a living. The respectability of men's white-collar work was also well established, and boys trained for the new middle class learned mathematics, science, and linear and perspective drawing. A generation earlier, working for another man could never have provided "independence," but now dependence had been limited to those who received charity, to those who pursued the service occupations, and to wives and daughters. Adult

[21] On the rescheduling of girls' schooling see House of Refuge, Minutes of Visiting Committee (HR-A201), 22 and 26 May 1829; and House of Refuge, Superintendent's Daily Log (HR-B-1), 26 May 1829. The boys' schoolwork was scheduled before breakfast and after supper. On the girls' improved attendance see House of Refuge, Minutes of Visiting Committee (HR-A201), 2 June 1829; and House of Refuge, Superintendent's Daily Log (HR-B-1), 19 June 1829. Related comments on schooling appear in House of Refuge, Minutes of Visiting Committee (HR-A201), 3 Apr., 22 May 1829.

independence, redefined, remained a central goal for educators of white boys of any economic background.

Ideas about race as well as class and gender were by midcentury entwined with ideas about appropriate work and economic status in the programs and reports of educational institutions. The House of Refuge, for example, opened a new Colored Department in 1850. Within the institution, technical education was gender appropriate and therefore similar on either side of the stone wall separating the races. Girls learned housewifery, and boys performed simple tasks like caning chairs. When children were apprenticed out after a year or two of reform, however, racial differences became more salient. Many boys of both races were apprenticed to farmers, and boys from the White Department were apprenticed to craftsmen such as carpenters and shoemakers. Nonfarming boys from the Colored Department were apprenticed to barbers or waiters. In this sense colored boys shared much with the girls: colored or white, a girl successfully apprenticed to "housewifery" was viewed as a "valuable servant."[22]

While all white boys in these institutions were trained for independence, they were certainly not trained in identical ways. Boys from the Girard College for Orphans — white, born in the United States, and never classed as "delinquent"-were rarely apprenticed to shoemakers, but most likely to printers or druggists. Where boys at the refuge had had a few hours of schooling before and after work, the most advanced portion of the Girard curriculum included geometry, algebra, trigonometry, natural philosophy, history, geography, grammar, French, Spanish, writing, bookkeeping, and architectural, mechanical, and perspective drawing.[23] Girard boys were educated for upward mobility, not unlike the "desirable young men to be trained to business" graduating with diplomas from Philadelphia's Central High School.[24]

The opposition of science and labor becomes even clearer when one reads the arguments about adding a workshop for the boys at Girard. By the end of the 1850s, some managers claimed that a workshop would produce healthy, well-rounded boys and would enhance their attractiveness in the apprenticeship market. To other directors, however, a workshop sounded suspiciously like manual labor and was therefore to be avoided. It took some years before the managers resolved the problem by hiring, in 1863, a "Professor of Industrial Science including Polytechnics." The curriculum mixed study of physics, chemistry, and anatomy with "applied mechanics" and "applied chemistry." The president of the board of directors reported that year that

[22] For apprenticeship data see, e.g., House of Refuge, *Annual Report* [for 1854] (Philadelphia, 1855), pp. 19, 52, and other annual reports from the 1850s. Excerpts of letters from masters were often printed in the annual reports. On servitude see also Faye E. Dudden, *Seizing Women* (Middletown, Conn.: Wesleyan Univ. Press, 1983). For extensive discussion of the transitional period at midcentury see Nina Lerman, "Preparing for the Duties and Practical Business of Life: Technological Knowledge and Social Structure in Mid-Nineteenth-Century Philadelphia," in *Gender and Technology,* ed. Lerman *et al.*

[23] Apprenticeships for 1854 are listed in Louis Romano, *Manual and Industrial Education at Girard College, 1831-1965: An Era in American Educational Experimentation* (New York: Arno, 1980), App. G, pp. 337–340; for the Girard curriculum see p. 94 n. 26.

[24] Philadelphia Board of Public Education, *Annual Report* [for 1850] (hereafter cited as Board of Public Education, *Annual Report* [year]), p. 118, quoted in David Labaree, *The Making of an American High School: The Credentials Market and the Central High School of Philadelphia, 1838-1939* (New Haven, Conn.: Yale Univ. Press, 1988). p. 20.

"those, therefore, who predicted that Girard College was to be leveled down to a manual-labor school have been mistaken." Even this solution proved short lived; within three years both president and professor were gone, and the issue remained inconclusively resolved until the early 1880s.[25]

Wage work for women raised its own complex issues. By the 1850s paid work outside the home was part of the economic life of a growing number of women, although they were generally excluded both from clerking activities and from learning the precise forms of industrial drawing, like drafting. Women taught the vast majority of Philadelphia's students and worked in textile mills, in addition to the more traditional domestic jobs like paid needlework or laundry.[26] Wherever they worked, however, women's pay was based on the assumption that women were supported by men, even though many of the women seeking paid work were doing so because they supported themselves and often their children. The better-paying jobs in industry were known as "skilled work" and also as "men's work; they required training boys might acquire in shop apprenticeships or possibly in evening programs at several local institutes. Girls had access to no such opportunities. The rhetoric of educators and of employment kept women domestic and dependent always. Even when girls were learning industrial textile design at the Philadelphia School of Design for Women, supporters sometimes claimed that "these arts can be practiced *at home,* without materially interfering with the routine of domestic duty, which is the peculiar province of women." In practice, however, advanced students used the school's facilities after classes to execute paying jobs. Wood-block printing and lithography were hardly parlor activities.[27]

Continued comparison of institutional programs reveals layers of entwined ideologies about social categories, work, and technology. Manly work, by midcentury, was performed away from home, the female domain. White, manly work supported one's family but was not service, a distinction that helps explain the relative prestige of manufacturing work even when the worker could expect to have little control of the process. Middle-class, white, manly work was demonstrably abstract, precise, or quantified, in contrast to soft, intuitive, or even imprecise female thinking, to a

[25] On the proposed workshop see Girard College, *Twelfth Annual Report* [1859], quoted in Romano, *Manual and Industrial Education at Girard College* (cit. n. 23), p. 138; the new curriculum is described on p. 158. Apparently some Girard boys also learned shoemaking on campus, which Romano reports "had proved to be self-supporting." The president's remarks are quoted in Cheesman A. Herrick, *History of Girard College* (Philadelphia: Girard College, 1927), p. 232. By the 1880s "manual training" had become a respectable part of the high school curriculum; see the discussion later in this essay. See also Herrick, *History of Girard College,* Ch. 8; and Romano, *Manual and Industrial Education at Girard College,* Ch. 3, pp. 140-164.

[26] In the 1850s, fewer than 10 percent of Philadelphia's teachers were male; see Labaree, *Making of an American High School* (cit. n. 24), p. 98. On boys' high school education see *ibid.;* on girls' see John Trevor Custis, *The Public Schools of Philadelphia—Historical, Biographical, Statistical* (Philadelphia: Burk & McFetridge, 1897). Also useful on drawing is Peter Marzio, *The Art Crusade: An Analysis of Nineteenth-Century American Drawing Manuals, Chiefly 1820–1860* (Washington, D.C.: Smithsonian Institution Press, 1976).

[27] Letter of Sarah Peter, "At a stated meeting . . . held April 19, 1850," *Proceedings of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, Relative to the Establishment of a School of Design for Women,* Library Company of Philadelphia, p. 1: Philadelphia School of Design for Women, *First Annual Report* (Philadelphia, 1854), pp. 16, 17. For a history of PSDW see Nina de Angeli Walls, "Art, Industry, and Women's Education: Philadelphia's School of Design for Women, 1848-1932" (Ph.D. diss., Univ. Delaware, 1995).

range of stereotypes about black male passions, and to the experienced bodily knowledge that characterized the workingman's manual labor.[28] Science, symbolically, might now distinguish one from *multiple* "others." As the century progressed, "science" not only betokened content but also carried a new connotation — all the best of American progress.

"LABORATORY METHODS OF EDUCATION": MANUAL TRAINING FOR COLLEGE AND FACTORY

In the last decades of the nineteenth century urban America was, if anything, a more confusing and complex locus of growth and activity than at midcentury. Yet in some ways Philadelphia educators saw their world clearly. First and foremost, education was the realm of experts. Childhood learning should be guided by professionally trained educators. Increasingly, school education included all forms of "preparation for life," and various forms of technical education entered the public schools of Philadelphia and elsewhere. Here, too, educators might invoke clear understandings about the adult futures of many of their young charges and blend social and educational goals in a range of curricular channels and opportunities. Under rubrics ranging from manual training to industrial arts, girls were taught cooking and sewing and boys were taught various forms of drawing and shopwork. But similar labels often belied differences in content, traditional distinctions reinterpreted with the confident stratification of the new Industrial Age.

A brief examination of technical education programs in Philadelphia's public schools illustrates these alternatives and returns us to the discussion of "women, gender, and science" central to this volume. The well-known manual training movement was the invention of engineering educators mourning the loss of the "Yankee whittling boy" and setting out to train "the mind, the eye, and the hand together"— "the whole boy is put to school."[29] The movement focused at first on secondary-level schooling, where boys would learn not only high school–level academic subjects but also mechanical drawing, woodwork, and metalwork. Then, under the combined influence of professionalizing engineers and professionalized "schoolmen," manual training was adapted to the needs and circumstances of younger students and girls: cardboard construction, paper folding and cutting, sewing, and cooking were added to the standard shopwork methods. Proponents argued that manual training would improve all students, not just those planning careers involving shopwork. These claims of universal benefit meshed with the prevailing "common school" rhetoric, in which material was deemed appropriate to the public schools when it was considered relevant to all students. Proponents of manual training frequently reminded audiences that such training was not trades training and was not specific to the student's future vocation. This distinction, however, did not mean that "manual training" was practiced in a monolithic fashion. Technological knowledge for the "whole

[28] See David Roediger, *Wages* of *Whiteness: Race and the Making of the American Working Class* (London/New York: Verso, 1991), for a psychodynamic assessment of white workers' ideas about race.

[29] See, e.g., Calvin Woodward, "The Fruits of Manual Training" (1883), in *American Education and Vocationalism: A Documentary History,* ed. Martin Lazarson and W. Norton Grubb (New York: Teachers College Press, 1974).

boy" was provided primarily to white, middle-class males; for nonwhite, poor, or immigrant males and for females, technological knowledge was taught for either moral or vocational purposes.

Philadelphia's first manual training school, Central Manual Training School (CMTS), opened its doors in 1885. CMTS exemplified the original goals and methods of the national manual training movement. The three-year high school-level program, for boys only, emphasized drawing and shopwork alongside standard academic subjects in order to educate "men who combine in one person the thinker and the doer." CMTS prepared its students for business and industry or for college; many so-called Manual Boys eventually received degrees in engineering. As principal William Sayre explained to the entering class in 1890: "You must not think you are coming here to learn a trade, to be a blacksmith, or a carpenter, or to turn out doctors and lawyers. You are to make use of manual training as you do of algebra, as a means to an end. Manual training is only valuable as it brings out thoughts and mental action. The education of all the faculties, the head and the hand."[30]

This thoughtful side of manual training was enhanced by an emphasis on drawing. As the catalogue of the school explained in 1890, "From the conception of the idea to its expression in the concrete material, the drawing is the medium through which the mechanical processes are largely developed, and brought to a definite and practical form." Drawing had been a standard part of public school instruction at all levels since the 1870s. In the 1879 elementary course of study, as at the Normal School decades before, drawing was usually paired with penmanship. But drawing was also increasingly understood to be related to manual work: after a revision of the elementary school drawing curriculum, the 1881 drawing classes for teachers were organized by the Committee on Industrial Art Education. Even so, drawing maintained a status never reached by shopwork; the drawing classes at venerable Central High continued throughout this period.[31]

In 1890 CMTS boys spent half of their six hours in school each day on manual training: one hour for drawing and two more for shopwork. During the first two years the boys progressed from woodwork to cold metal to hot metal techniques. By the third and final year, a boy's shopwork had progressed to mechanical construction, culminating in a class project such as "a steam engine, a dynamo, or some other machine." As one manual training proponent explained in a talk to the American Society of Mechanical Engineers, the purpose of construction work was to show the boys that they were prepared to do such work and to demonstrate to them that even after preparation, new problems requiring thought could always arise.[32]

Despite the success of CMTS and despite their continued conviction that, indeed, the whole boy should be put to school, by 1894 Philadelphia's manual training proponents found themselves relying on an entirely different strategy to justify their program:

[30] Quoted in A. 0 . Michener, *A History of the Northeast Manual High School* (Philadelphia: Alumni Association of Northeast High School, 1938), p. 38.

[31] *Catalogue of the Manual Training Schools, 1890–91* (Philadelphia: Board of Public Education, 1890), p. 21. On the status of drawing in the new curriculum see "Drawing" and "Object Study" in revised curriculum, *Journal of the Board of Public Education* (Philadelphia, 1880), App. 3. On drawing classes at Central High see Labaree, *Making of an American High School* (cit. n. 24).

[32] *Catalogue of the Manual Training Schools, 1890–91,* p. 23. The address of Calvin Woodward cited in the text is quoted in Charles Bennett, *History of Manual Training and Industrial Education, 1870-1927* (Peoria, Ill.: Charles A. Bennett, 1937), p. 358.

> The shop instruction is simply part of the laboratory methods of education.
>
> The term "shop" in this connection is as much of a misnomer as is the term "manual training" when applied to the whole school.
>
> It would seem more fitting, therefore, in speaking of the shop, to call it a *laboratory,* a term which carries with it the educational significance of its work. The name, however, is so closely identified with the kind of instruction given, that it is not easy to change the nomenclature.

Whether to attract parents or convince board of education members that this was not a "trades school," the authority of university faculty and professional educators was insufficient; for middle-class high school boys the manual training curriculum had to be justified, rhetorically, as science.[33]

The boys at CMTS learned the principles and theories underlying complex technologies and had the opportunity to work with the machines they had studied. They also pursued academic courses in the sciences and humanities that prepared them for college, if they chose to go — and more than a few of them did so. CMTS students were an elite group both because their families could afford to let them attend school at an age when many boys went to work and because they had achieved the highest scores in their local grammar schools on the entrance exam. The school's curriculum was designed to teach them initiative in all things, partly by teaching them mastery of theory and machines. As the catalogue put it in 1890, the school intended "not to make mechanics, but to train boys for manhood."[34]

The other manual training school the board of education established was intended for a population very different from that of CMTS. The James Forten School had been a "colored" school, but by the end of the 1880s Italian, Polish, and Russian immigrants were moving into tenements left behind by any African Americans who could afford to move. In 1890 the board reopened the school as the James Forten Elementary Manual Training School, employing a specially hired cadre of teachers who went door to door throughout the neighborhood to encourage local children to attend.[35]

Forten's new curriculum was aimed primarily at foreign students. The president of the board explained that children who could not speak English could not profitably attend ordinary schools. He asserted that "a school in which elementary manual training should be combined with primary school work, in the English language.

[33] *Catalogue of the Central Manual Training School, 1894–95* (Philadelphia: Board of Public Education, 1894), p. 29. A decade later the principal was still arguing the point: "The 'drawing' of the exercise is the 'question stated,' and the concrete result in wood or metal is the educational product. Treated from this standpoint, the exercises become 'problems' in wood or metal, and the logical processes thus evolved make manual training rise to the level of scientific or mathematical studies as a means of mental development. The exercises cease to be mere mechanical imitations, and the trade school idea is banished." "Report of the Principal of Central Manual Training High School," in Board of Public Education, *Annual Report* [for 1905].

[34] *Catalogue of the Manual Training Schools, 1890-91* (cit. n. 31), n.p. It also explains, "In the changing conditions of the thing in hand during its construction, there is a constant necessity for creating new means to meet new requirements, and the directive skill thus involved makes manual training rise to the level of scientific or mathematical studies as a means of intellectual development" (p. 22).

[35] In 1892, 162 of 350 students (46.3 percent) were "colored": the proportion remained just under half until the mid 1890s. It dropped to 43.9 percent in 1895, to 30 percent in 1896, and to 12.6 percent of 572 students in 1899. These data are drawn from Frederic Speirs, "The James Forten School: An Experiment in Social Regeneration through Elementary Manual Training," paper presented to the Civic Club of Philadelphia, 2 Mar. 1901.

would benefit the community by helping these children to a better life."[36] Manual training stood at the forefront of progressive educational reforms, so it is not surprising that progressive educators used manual training to educate immigrants. Even so, the close association in the minds of the reformers between manual training and better lives for immigrant children emphasizes its different purposes at Forten and CMTS.

These differences are evident both in the justifications given for the Forten curriculum and in its technological content. Hannah Fox, the new principal of Forten, reported in 1891 that "the object of the manual training work [was] not only the cultivation of the hand and eye, but also to teach habits of accuracy, neatness, dispatch, and obedience." Forten teachers promoted a Swedish woodworking method, known in the United States as "Sloyd." At Forten, Sloyd was meant, like high school–level manual training, to teach a boy to think; but in addition it would "teach a boy to be neat and orderly, to be careful and accurate, [and] to be honest and truthful," claims not made for the CMTS curriculum.[37] At Forten, honesty was the remedy for the new "subversive influences" of the immigrant population, "which in our early history were absolutely unknown." The pedagogy of Sloyd matched its purposes at Forten. In Sloyd each wooden object was referred to as a "model," which was chosen by the teacher. The students' task was to make careful copies. Variations on this system used paper and cardboard rather than wood, but in all cases each student produced an exact replica of the teacher's model.[38]

Some girls learned Sloyd, but it was mostly the domain of boys. Manual training for girls generally entailed cooking and sewing. Beginning in 1888, girls in selected public schools took cooking classes, using standard printed recipes and moving from simple to more complicated food preparation. The girls were eventually taught the "scientific branches of the work," including the composition of foods and their effects upon the body. At Forten, however, it was found "necessary to adapt the regular course of instruction": "The attention of these pupils is directed to the necessity of preparing food plainly and economically, to avoid waste, and of so utilizing material as to produce the best results — they are taught habits of cleanliness and neatness and a desire for such habits is created."[39] Educators clearly presumed that such habits were not taught in students' homes and that, unlike grammar school girls, elementary-level immigrant girls did not need the "scientific branches" of cookery.

Drawing, too, played a different role at Forten. Hannah Fox's description contrasts with the rhetoric employed at CMTS: "The intelligent construction of a working drawing, the reproduction in wood of the article drawn, together with the correct use

[36] Board of Public Education, *Annual Report* [for 1891], p. 17.

[37] *Ibid.,* p. 126; and Board of Public Education, *Annual Report* [for 1892], p. 137. The claim that Sloyd would promote honesty was echoed often, and occasionally far afield: in an article on "accuracy in clinical work," for example, the physician Richard Cabot argued, "An enthusiastic advocate of manual training in the public schools once said in my hearing that a boy who had had a thorough course in sloyd work would never tell a lie. In this obviously exaggerated statement there is, I think, this much of truth: such a boy will find it much *harder* in the future to lie." Cabot went on to discuss the importance of observation and data. Richard C. Cabot, "The Ideal of Accuracy in Clinical Work: Its Importance, Its Limitations," *Boston Medical and Surgical Journal,* 24 Nov. 1904, *151*:557.

[38] Isaac Sheppard, President of the Board of Public Education of Philadelphia, quoted in Board of Public Education, *Annual Report* [for 1891], p. 10. On Sloyd see, e.g., Everett Schwartz, *Sloyd or Educational Manual Training with Paper, Cardboard, Wood, and Iron for Primary, Grammar and High Schools* (Boston: Educational Publishing Co., 1893).

[39] Board of Public Education, *Annual Report* [for 1892]. p. 137.

and proper care of tools, must yield skill, we believe, that will be of service in almost any trade, and will also promote habits of neatness, accuracy, persistence, and concentration.[40] Again, manual training was taught in different ways because it was used for different social purposes. Forten teachers focused on "reproduction" of models and "correct use" of tools: CMTS teachers focused on understanding, exploration, and design. Similarly, the standard girls' cooking curriculum introduced "scientific" discussion of theory. Forten students, learning how to be American, were taught to follow directions. CMTS students were expected to issue them.

Manual training was also justified as particularly suitable for Forten children because it was vocationally appropriate. Forten students were given an education tailored to the factory jobs their teachers and the board assumed they would soon hold. Thus "moral" and "vocational" had overlapping meanings: the best "vocational" preparation for entry-level factory and manual jobs was the development of "moral" skills such as neatness, punctuality, and obedience. In cases where the student's vocation was easily predicted, training for that vocation could be enlisted on the side of morality. For these students vocational preparation was moral, and moral training was vocational.

Despite the nonvocational nature of the common school model, there was one other group of students who had been provided with vocationally oriented training early in the decade. In 1881, before the opening of CMTS or Forten, sewing was introduced in the Girls' Normal School. The Girls' Normal, originally established for the vocationally oriented purpose of training teachers, remained the city's only public school for girls who wished to continue their education beyond grammar school. By 1880, however, Philadelphia was experiencing a glut of teachers: part of the board's purpose in adding sewing to the curriculum was to provide the girls with alternative remunerative skills. The report on the subject, prepared jointly by the Committees on the Girls' Normal School and on Industrial Art Education, began broadly nonetheless: "The importance of all branches of study which are of practical value in connection with any of the industrial pursuits, will scarcely be questioned. Furthermore, we believe that all women should have a knowledge of the art of sewing, whether they do or do not turn that knowledge to practical uses."[41] We may deduce, in this case, that "practical" stands in contrast to "domestic." While the vocations of most grammar-school boys in the 1880s were considered open ended, girls' vocations were few and clearly defined. Subject matter "of practical value" to girls was therefore easy to identify and uncontroversial. Sewing was introduced for all grammar school girls by 1885: cooking—a more expensive undertaking—followed in 1887 at the Normal and in the following year (as we have seen) at selected grammar schools.

By 1897 the board had established cooking centers in seven locations for the use of grammar school girls, but although similar shop centers for boys had been recommended in 1893, funds were not allocated for them. The facilities at the Forten School, in its poor immigrant neighborhood, were used by students at other nearby schools, but not until 1909 did boys elsewhere take shop courses. Such budgetary decisions reflect the priorities of the decision makers; the "reform" of cooking for

[40] Board of Public Education, *Annual Report* [for 1894], p. 104.

[41] *Journal of the Board of Public Education* (Philadelphia, 1881), App. 48. A general high school, Girls' High School, opened in 1893.

girls was either more important to proponents or less objectionable to detractors than that of woodworking for boys. Reform rhetoric about cooking lessons stressed the usual arguments about the educational value of manual training, but also consistently mentioned the usefulness of the skills involved for the students learning them. All girls would need to cook as adults, but not all boys would need carpentry skills. Vocational value, and not moral or educational content, dictated the spread of grammar school cooking.

In fact, the shopwork at CMTS, especially for boys going on to work in industry or to study engineering in college, also had a vocational purpose. But in the particular context of late nineteenth-century class and gender relations, it could never be justified as such. Instead it was labeled "science" — an argument somewhat at odds with the manual labor connotations of training the hand along with the head and the eye. In a period of notable labor "unrest," it is perhaps not surprising that the "manual" part of manual training lost out, that as the school grew the boys spent less time in shopwork and more time on high school subjects. The difficulty can perhaps be located in the explanation of an advocate of Sloyd: "We no longer absolutely despise hard bodily labor as we did a century ago, when to do nothing was considered more honorable than to work; yet even to-day we attach a certain stigma to all forms of bodily labor. In the social world, the clerk ranks higher than the skilled artisan, and the workmen themselves are only too apt to consider that their labor is less honorable than that of their masters."[42] In the social world, he might have added, the factory operative ranks lower yet than the skilled artisan. As the example of the Forten School suggests, the new male "other" for the middle class had become a factory hand, not an artisan.

HIERARCHIES AND BOUNDARIES: THE USES OF USEFUL KNOWLEDGE

By the end of the century, when the early upheavals of industrialization had largely been worked out for the urban middle class, traditional patrician "separate spheres" concerns with gender roles had to some degree given way to the more pressing concerns of immigrant lifestyles and labor unrest. Protestant, middle-class, native-born women had rendered their domestic prerogatives powerful in urban reform; cooking, too, might now have its "scientific branches." And yet domesticity remained central in all discussions of female education. Social boundaries shifted with new urban configurations, but by no means were they erased from the institutions of modern education.

Of the many themes emerging from this discussion, several must be emphasized here. First, it should be clear that technological knowledge carried social meanings, which in turn influenced and were influenced by the social differences among people possessing that knowledge. The literary content of schooling, as well, represented far more than simply one's ability to read, write, and cipher or to read French or Latin. Schooling throughout the century was a badge of American respectability; educators increasingly succeeded in winning control over a system of credentials

[42] On the decreasing place of manual training see the *Catalogue of the Manual Training Schools* for 1890, 1894, 1898, and 1910. The academic work per week averaged 15 hours in 1890, 18.7 hours in 1910; manual training per week averaged 15 hours in 1890, 11.3 hours in 1910. The quotation is from B. B. Hoffman, *The Sloyd System of Woodworking* (New York: American Book Co., 1892), p. 25. The author was superintendent of the Baron de Hirsch Fund Trade Schools in New York City.

that was in turn supported by those who had access to them.[43] School not only inculcated social values but was a product of them; it carried meaning independent of the skills it taught, and the possession of such skills carried meaning independent of their day-to-day usefulness. Schooling had meaning in the social hierarchy; book learning and manual training alike had meanings in the knowledge hierarchy.

But beyond the simple respectability that attached to sending a child to school, familiarity with and reliance on written communications—drawings, words, and numbers — had become increasingly important during the century in business and manufacturing practice, as implied by the emergence of white-collar work as a separate category. These written forms had also become an increasingly important part of the transmission of technological knowledge and had gained status in perceived hierarchies of technological knowledge, as the leaders shaping the scientific, mathematical, and drawing-based curriculum of schools like Girard, Central High, and CMTS well knew. Such hierarchies informed and reconfigured each other; both school-based credentials and the use of precise abstractions became tools with which an individual or group could raise itself in the social order, and status in the social order made it easier to acquire both diplomas and familiarity with modes of technical expression, written and drawn.

Second, the examples presented here — and they are by no means the whole range available — demonstrate the breadth of activities we must include in the realm of the "technological" and invite further discussion of the cognitive and social authority of "science" in the nineteenth century. The separation of "science" from the "useful arts" became increasingly complete as the century progressed, suggesting that our modern definition of "science" is no less conditioned by the social, economic, and mechanical processes of industrialization than are our assumptions about "technology.[44] Those assumptions. after all, came partly from an active campaign by engineers to link their work with the mathematics and theory of science. We need not be bound by them.

Finally, crossing these social boundaries in the study of science itself is more complex: these boundaries have been part of the very definition of what counted as "science." The hierarchies illuminated here by comparisons in technical education across social boundaries can raise important questions for scholars interested in gender and science. These examples remind us that there are multiple masculinities and multiple femininities available within a culture; throughout the century distinctions were made in the education of different groups of boys or groups of girls. Have there been and are there, symbolically, multiple sciences too? In the institutions I have discussed, science was invoked sometimes for its content and sometimes for the

[43] On credentials see Labaree, *Making of an American High School* (cit. n. 24); Shan Nelson-Rowe, 'Markets, Politics, and Professions: The Rise of Vocationalism in American Education" (Ph.D. diss., State Univ. New York, Stony Brook, 1988): and Michael B. Katz, *The Irony of Early School Reform: Educational Innovation in Mid-Nineteenth Century Massachusetts* (Cambridge, Mass.: Harvard Univ. Press. 1968).

[44] Indeed, the formal institutions of American science — as opposed to the useful arts — emerged with American industry in the 1840s and 1850s. As Sally Gregory Kohlstedt has suggested, these institutions do not mark the *beginning* of American interest in science, which was widely evident in a range of other forms throughout the decades of the early republic. See Sally Gregory Kohlstedt, "Parlors, Primers, and Public Schooling: Education for Science in Nineteenth-Century America," *Isis,* 1990, *81*:425-445.

prestige the label conferred. Further, the content of science provided part of the prestige.

These uses are entwined and entangled both in historical documents and in the present, but with care we may begin to make analytical distinctions. If "science" has meanings on many levels, then it must be treated in a way not unlike our treatment of gender: it has structures and institutions; it produces knowledge; it also functions symbolically, as a cultural product. As such, it demands sustained attention to borders, to boundaries, and to "others": to both science and not-science, and to the changing boundaries between them. In what ways are gender, race, and class intertwined or differentiated by the meanings of science? Which dimensions are salient when, and why? When we study knowledge historically, we depend on descriptions and accounts of that knowledge rendered in the past to make new accounts rendered in the present.[45] With "science," as with gender or race, we must find ways to cross the boundaries our sources impose on us; otherwise we confine ourselves to an understanding limited by the separate spheres and categories of another time.

[45] Both Joan Scott and Sandra Harding have discussed gender as identity, structure and institution, and representation. See Joan Wallach Scott, "Gender: A Useful Category of Historical Analysis," in *Gender and the Politics of History* (New York: Columbia Univ. Press, 1988); and Sandra Harding, *The Science Question in Feminism* (Ithaca, N.Y.: Cornell Univ. Press, 1986). Judy McGaw has argued for interrogating rather than accepting our sources' views of gender in "No Passive Victims, No Separate Spheres" (cit. n. 2).