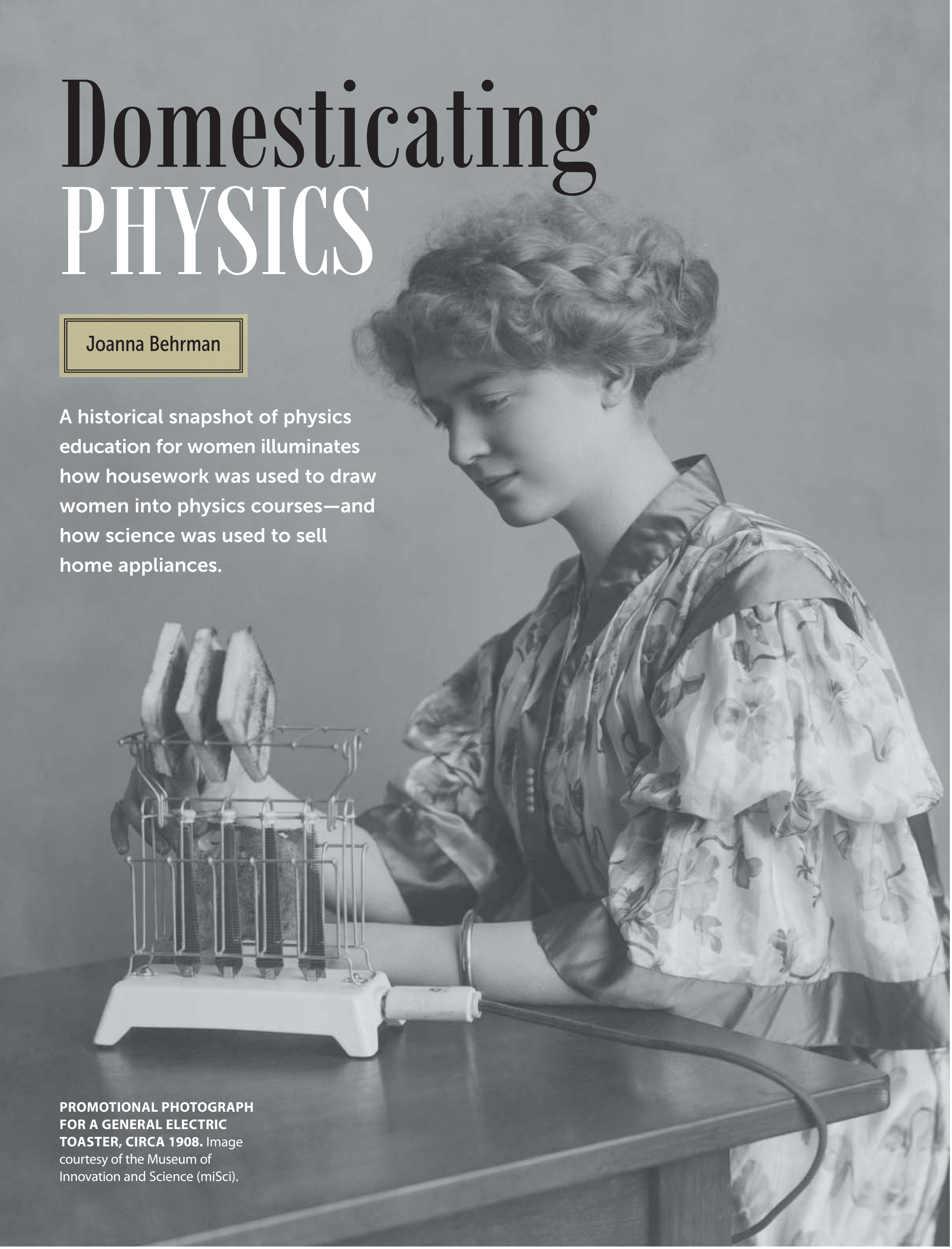
Domesticating PHYSICS

Joanna Behrman

A historical snapshot of physics education for women illuminates how housework was used to draw women into physics courses—and how science was used to sell home appliances.



PROMOTIONAL PHOTOGRAPH FOR A GENERAL ELECTRIC TOASTER, CIRCA 1908. Image courtesy of the Museum of Innovation and Science (miSci).

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One hundred years ago, the average American household was a very different place from what it is now. Gas for lighting and heating was still fairly common, particularly in rural homes. Few households had electric coffee makers, toasters, vacuum cleaners, or refrigerators. The ubiquity of those items in American homes today is a testament to a decades-long campaign not just by manufacturers but also by scientists. Beginning in the 1910s, people in business, government agencies, and university departments reached out to housewives to encourage them to learn about, try, and buy new technologies. Housewives, however, were not easily won over; supporters of the new technologies found that their potential customers were budget conscious, skeptical, and even fearful of the unfamiliar devices. To overcome those concerns, American physics teachers, in cooperation with home economics departments, created a new field of education: household physics.[1]

Born out of efforts to make physics more "relevant" to female students, household physics courses in high schools and colleges applied the basic introductory physics curriculum to technological problems of the modern household. Professors extensively tailored physics material toward what were assumed to be the needs of their female audience. As one popular textbook put it, "So many things are done with the aid of electrical energy that this is sometimes spoken of as the 'electrical age,' and a housewife is now expected to know what was formerly deemed necessary only for a scientist."[2]

Household physics courses were created not just to educate, but also to sell. The courses attempted to mold students into a specific ideal of the modern housewife: a scientifically informed consumer who no longer feared but welcomed technological innovation. Nonetheless, even though students learned a great deal of the science behind new technologies, the range of what they were encouraged to *do* with that knowledge was still carefully circumscribed by rules of gender and class.

This article will explore the ways in which household physics courses cultivated a female student's relationship with technology by examining textbooks used for those courses. Household physics textbooks contained much standard material for an introductory physics curriculum, but they also encouraged readers to form a connection with commercial technologies. The textbooks incorporated images of new household devices provided by commercial firms, promoted knowledge of and confidence around those devices, and asked students to practice consumer skills in their laboratories and homework problems.

Origins of household physics

In the early 20th century, the physics education community was in a panic over what appeared to be a crisis of enrollment. The number of students in US high schools rapidly increased in the first decades of the 20th century, but few of those new students seemed drawn to physics courses. The US Bureau of the Census records that 19% of all secondary school students were enrolled in physics classes in 1900, but that percentage dropped to 14% in 1915 and 7% in 1928.[3] In terms of absolute numbers of students, enrollment in physics classes was not dropping drastically, but it did not increase at a rate equal to the rapidly increasing number of students overall. In essence, physics constituted a decreasing portion of a curriculum whose offerings were expanding to include options such as new vocational and home economics classes.[4]

Physics educators advocated popularizing physics by making it more relevant to students' daily lives, especially for students who did not plan to attend college. Popular textbooks such as Robert Millikan and Henry Gale's *Practical Physics* (1906) emphasized topics and homework problems that would closely connect with the students' lives—particularly male students'. Illustrations and examples were often based on technologies of industry and war, such as airplanes and automobiles. College-level textbooks before World War II tended to employ a similar approach that emphasized applications of physics rather than its theoretical side (see Charles Holbrow's article, PHYSICS TODAY, March 1999, page 50).

Educators and publishers soon realized that they could also connect physics with students' lives at home. In 1914 the Macmillan Company published one of the first household physics textbooks, *Physics of the Household* by Carleton Lynde. Macmillan and Lynde followed up in 1919 with a laboratory manual meant to accompany the course. Unlike subsequent household physics books, Lynde's texts were not directed solely to female students. He intended that *Physics of the Household* be transferable to a student's everyday life. Topics included fire extinguishers, the water supply system, the telegraph, the telephone, and the camera.[5]

Even though Lynde wrote his textbook for a mixed-gender audience, the book became popular among many physics and home economics instructors specifically as a way to teach female students. Science educators thought that physics curricula underserved female students because, they argued, the topics of physics class connected least with a girl's everyday life or her needs as a student. Household physics courses became popular because educators saw them as a way to make a basic physics education appeal to women. Other textbook publishers soon came out with their own versions of household physics books, including Walter Whitman's *Household Physics* from Wiley (1924) and Frederick Osborn's *Physics of the Home: A Textbook for Students of Home Economics* from McGraw-Hill (1929).

FIGURE 1. A WOMAN REACHES BEHIND HER TO FLIP THE SWITCH on a circuit breaker. (From Madalyn Avery's *Household Physics*. Original material courtesy of Schneider Electric.)

The most influential and popular household physics textbook, however, was almost certainly *Household Physics: A Textbook for College Students in Home Economics* by Madalyn Avery, first published in 1938. Avery took over Macmillan's household physics line after Lynde's departure. Like other authors in the genre, she was trained in physics, not home economics. She earned her bachelor's in general science in 1924 and her master's in physics in 1932, both at Kansas State College of Agriculture and Applied Science (later Kansas State University).

Avery built her career at Kansas State College working at the junction of applied physics and home economics. Like many women of her generation who were trained in science, she found greater acceptance and respectable employment by concentrating on scientific problems traditionally associated with women.[6] Avery's last work in mainstream physics was her master's thesis, entitled "The absorption of ultra-violet light by solutions of plant pigments." For the majority of her career she taught and researched household physics—and she was the only female author of a household physics textbook.

Household Physics was Avery's major publication and an object of personal pride. After the 1938 first edition, she published a laboratory manual in 1940 and revised editions in 1946 and 1955.[7] By mid-century Avery's books were used in more than a hundred colleges and universities around the world.

Knowledge and safety

A central goal of household physics textbooks was to alleviate potential fear and discomfort around new household devices. Avery and other household physics authors attempted to familiarize their readers with new technologies and equip them with the knowledge they needed to use them safely. Authors like Avery and Lynde emphasized that new technologies could be dangerous, but only because of ignorance or carelessness. Proper education would give the student confidence, control, and good judgment.

An important first step toward alleviating fear was to compare older, trusted technologies with new ones. For example, students unfamiliar with electrical heating appliances were likely brought up in a household that used gas or kerosene for heating. Avery compared electrical heating favorably with combustion-based heating and urged students to feel as comfortable with electricity as with gas, if not more so.

Avery also responded to safety concerns by teaching readers how to operate devices safely. Household physics textbooks included safety tips on the use of household technologies, and students also learned about the scientific principles underlying the workings of a device. For a deep-fat fryer, for example, Avery instructed students to plug the cord into a socket within close enough reach to be unplugged immediately if the fat caught fire. Moreover, the student should have a lid nearby to smother the flames. Students could apply that general principle to a wider variety of situations, such as smothering an oil fire by cutting off the oxygen supply. Scientific knowledge about combustion served as a way to reduce safety concerns and foster familiarity with a wide range of technologies based on the same principles.

Understanding how and why something works can increase a person's comfort around a particular object. Avery used that trajectory as an educational strategy in her textbooks. For example, before introducing the topic of space heaters, she taught her students about heat conduction. She then used the knowledge the students had gained to reassure them about the safety of a particular device, in this case a glass-sided space heater;

FIGURE 2. A TEMPERATURE LABORATORY IN A 1938 HOUSEHOLD PHYSICS CLASS at Kansas State College. (Image courtesy of Morse Department of Special Collections, Kansas State University Libraries.)

she wrote, "Since glass is a poor conductor, if a child happens to put his hand on the glass he will have time to move it before he is burned."

With that piece of scientific knowledge, the space heater seemed safe enough to be incorporated into family life. Students learned from Avery that the heaters could keep food warm "for family meals or buffet suppers," or make the house comfortable "on cool mornings and evenings in a bedroom, bathroom, nursery, or dining room." The space heater with its cheerful glow was now understandable—thus unobjectionable—and could be comfortably integrated into the home.

It is worth asking how common it was for students to actually perceive new appliances as dangerous. The textbook authors acknowledged the widely known fact that electrical appliances could and did cause fires. And yet, a growing middle class increasingly bought and used electrical appliances during the decades when household physics textbooks reached their peak production.

Although some students may have had mixed feelings about new appliances, the textbook authors likely talked about household dangers in order to create an opportunity to expound on the virtues of new technologies. Moreover, although the textbooks acknowledged that the technologies were dangerous, Avery and other authors repeatedly assured readers that they were only dangerous if one did not have the proper scientific knowledge and attitude when using them. In essence, the textbooks set up a threat in order to assuage it. Thus the reader learned to appreciate the power and control of science. Moreover, by looking at the devices through the lens of knowledge, the student could clearly see the progress science had made in appropriately and beneficially integrating technology with daily life.

Household physics textbooks also consistently associated new appliances with positive traits. Cooking devices like electric roasters, toasters, and percolators were "a decided help in the kitchen and dining room." Avery often recommended the "useful return" such devices would bring through their "convenience, pleasure, and comfort." The textbooks also promoted household technologies by giving students the opportunity to personalize them. For example, homework problems challenged students to apply theories of color and illumination to design and personalize spaces in the home with new lighting and appliances.

Images

The images used in household physics textbooks encouraged students to get to know the objects they depicted. Avery used cross sections of appliances, for example, to foster familiarity. Irons, sewing machines, coffee percolators, and even toasters were all displayed in that manner. Interior, hidden knowledge was made visible and explained in the accompanying text. Cross sections could also show the device in action in ways not possible in real life. A reader could see coffee brewing in the coffee percolator and a chicken cooking in a pressure cooker. A device's internal structure was no longer hidden, mysterious, and potentially frightening. Cross sections revealed the inner nature, structure, and workings of a device.

But familiarity with the abstract knowledge behind a device was not enough. A student needed to associate that device with the place it would occupy in the home before she would conceivably buy it. Photographs of appliances in the home helped students visualize devices in action by placing them in a familiar context. Chapters on light and on the proper lighting of a home relied heavily on photographs for illustration. For example, Avery's *Household Physics* taught students about ray diagrams and wavelengths and then gave examples of how

FIGURE 3. A 1922 HOUSEHOLD PHYSICS LABORATORY CLASS comparing the efficiency of vacuum cleaners at Kansas State College. (Image courtesy of Morse Department of Special Collections, Kansas State University Libraries.)

different light fixtures would disperse light around the room. Next, photographs of model rooms illustrated how particular areas of the home ought to be lit. Should certain surfaces have direct or indirect illumination? Sharp contrasts or diffused light? The quality of the image printing in the textbooks did not necessarily make clear the distinctions the text emphasized, but the images nevertheless made the connection between physics knowledge and how a student might apply that knowledge in her own home.

Some illustrations included people interacting with the devices. Technologies were thus put into context in appropriate household rooms and tied to specific actions. On one page of *Household Physics*, a woman turned on the faucet of a large sink amidst other "modern plumbing fixtures for the laundry" while children played in the background. On the facing page another woman finished her toilette in a photograph of "modern plumbing fixtures for the bathroom."

A particularly striking photograph showed a woman taking a pause from her electric iron to flip the circuit breaker in her kitchen. The kitchen behind her was mostly dark, but as she turned to the circuit breaker her face was framed by a halo of light on her blond curls, revealing a faint smile (figure 1). The woman was perfectly at ease with electrical appliances of all sorts, including the refrigerator in the background, and was both figuratively and literally enlightened about the use of electrical technologies. Images like that one were similar to advertisements in the *Ladies' Home Journal* or other contemporary women's periodicals. The soft realism of such illustrations gave the reader a sense of intimacy and companionship with the person or object portrayed and nudged the viewer to desire what the picture showed.

It should therefore come as little surprise that commercial interests provided an enormous percentage of images for household physics textbooks. The photographs of lighting, for example, were usually provided by either General Electric or Westinghouse. That was not the case with mainstream physics textbooks such as Millikan and Gale's, from which commercial images were absent. Certainly, many of the pictures in household physics textbooks illustrated the principles outlined in the text, but many images also served as advertisements—for how a home ought to look, what products it should rely on, and what a woman's role was in that environment.

Practicing at home and in the laboratory

Household physics textbooks were meant to be accompanied by homework problems and laboratory courses. Through those activities, students practiced the principles they learned in the classroom. Avery's own household physics course used laboratory projects and homework problems both to reinforce physics principles and to encourage students to practice consumer skills and make personal connections to technologies (see figure 2).

Avery's laboratory manual contained 25 experiments divided into five sections, with six exercises in mechanics, seven in heat, five in electricity, two in sound, and five in light. Much of the material in the manual would not be out of place in a general physics laboratory. However, much was tailored to future housewives and consumers. Questions accompanying an experiment frequently directed the student's attention not to a further expansion of scientific principles, but to the domestic application of those principles. The students were asked to draw on their own experience in the home, utilize household devices of their choosing, or answer questions only incidentally related to the physics they were studying.

For example, the manual's set of activities titled "Graphical

FIGURE 4. A 1946 HOOVER ADVERTISEMENT draws on the idea of household technologies as status symbols and emphasizes their ease of use in a woman's hands. (Image reproduced with permission of Techtronic Floor Care Technology Ltd.)

Composition and Resolution of Forces" could have been lifted from a mainstream laboratory manual, except for the addition of a diagram showing the vector decomposition for pushing a vacuum cleaner. The student divided a force into horizontal and vertical components and learned how to balance the necessary force of the vacuum cleaner on the floor with the force needed to move the vacuum across the floor.

A subsequent laboratory activity titled "Vacuum Cleaners" connected only tangentially to physics (figure 3). In that experiment, students compared the relative cleaning efficiency of different brands of vacuum cleaners, the brands' available accessories, and initial versus long-term costs. The activity encouraged familiarity with the range of what was available in vacuum cleaners, and students practiced consumer skills by considering factors that would affect purchasing decisions. Many schools that used Avery's book would have held household physics laboratories in a model house or apartment, especially if the course was being taught in a home economics department. Those environments gave students ample opportunity to practice operating devices and the tasks of a scientifically minded consumer, such as comparing cost, efficiency, and personal preference.

In the homework problems as well, students made value judgements, gave personal preferences, and did cost–benefit analyses for various household devices. Students were encouraged to think about questions of price and fit. Were these devices appropriate for small or large home spaces? For what sort of household budget? Would they be used to cook, heat, or illuminate? Questions such as "Do you prefer a combination waffle iron and grill, or do you prefer separate devices? Why?" required readers to think about and mentally interact with objects at least enough to express a preference for a particular type. Even if the reader had felt no particular familiarity with a device previously, the textbook asked her to create at least a basic attachment.

One activity household physics students did not practice, or practiced only rarely, was making repairs to devices. Some basic repair directions were included in Avery's textbook, but the student was not asked to practice making the repairs herself. In fact, she was encouraged to turn to a licensed electrician for all repairs beyond basic maintenance. However, home appliance repair was a major focus of another type of home economics course that overlapped with the physical sciences: the "household equipment" courses taught at colleges such as Iowa State University in the early twentieth century.[8] Household equipment classes usually developed from home economics departments and in collaboration with engineering departments, rather than physics. In household equipment classes, female students became proficient at making general repairs to household devices.

A different role was envisioned for the student of each course. A student of household equipment became a tinkerer of technology, someone with the power to take apart and alter a device. A student of household physics was prepared for a more circumscribed role as a user or manager. Though the household physics student may have seen the interior of devices, potentially solely through cross-section images, she was not supposed to dirty her hands in their alteration. One advertisement for the third edition of Avery's textbook declared: "This is *not* a how-to-fix-it book; the emphasis is on understanding principles."

The enlightened student of household physics may have known how her device worked, but she was presumably of a gender and class where she could—even ought to—hire someone else to do repairs. The rejection of the how-to-fix-it approach reflected contemporary prejudices of both gender and class against women working as equipment technicians. Notably, most household equipment courses were developed by women, whereas with the exception of Avery's book and classes, men were generally behind the development of household physics.

Technology and progress

According to Avery (1946 edition, page xiii), a housewife needed to be able to control and manipulate the ever-more-rapidly advancing technologies in her daily environment:

> Since the beginning of time man has been compelled to obey the laws of nature. . . . It is only as he studied the laws of nature and found the answers to the question "why" and "how much" that he could intelligently use or oppose the forces

> of nature. . . . In order that she may use her equipment efficiently, as well as with ease and without fear, the housewife should understand the physical laws which govern the operation of these devices.

The motivation for learning physics, in other words, was to win a power struggle against nature. The housewife also faced a struggle that physics could help her win, although in her case "nature" was man-made. One advocate for household physics argued that household appliances were becoming part of a housewife's daily environment, and, as such, the housewife needed control over them in order to properly incorporate and use them in domestic life.[9]

A housewife needed to embrace not only current technologies but also those that would develop in the future. The textbooks subtly constructed a narrative in which the reader was at the better end of a timeline of technological progress. Many of Avery's chapters began with phrases such as "prehistoric times" or "as far back as the history of man goes." Other chapters contrasted modern Western progress with the technologies of "uncivilized people." Multiple textbooks drew on lighting technologies to illustrate "enlightened" progress. At least three textbook series used strikingly similar illustrations that displayed a progression of lighting technologies from a caveman holding a flaming stick, to oil-based lamps, to gaslights, to lightbulbs. To illustrate an *acceleration* of progress, Whitman's textbook series split the image of different types of lighting into two. The first image showed "six thousand years of progress in lighting from the pitch knot to the kerosene lamp," and the second displayed "fifty years of progress in lighting from the kerosene lamp to the electric tungsten lamp."

Household physics students were taught that learning scientific principles would enable them to keep up with that progress in the domestic sphere. According to the textbooks, since there is nothing inherently dangerous about technologies except when they are victim to human error and ignorance, the student could trust that her knowledge of physics would overcome any fear or unfamiliarity when the next technology came along. Physics knowledge gave her an advantage over technologies past, present, and future.

Legacy

After World War II, physics curricula moved away from an applied approach based on the students' everyday lives. That shift was due in large part to Cold War pressures and to government efforts like the Physical Science Study Committee, which encouraged teachers to focus more on a spirit of scientific inquiry and less on applications of physics knowledge.[10] Meanwhile, decades of work by manufacturers and scientists cemented the importance of household technologies as American status symbols (see figure 4). More and more, household physics seemed like a relic of a time when technologies of the home were not so prevalent and familiar. The household physics genre gradually fell out of favor in the 1960s and 1970s, and Avery's own course at Kansas State University stopped being offered after her retirement in 1970.

In the first half of the 20th century, however, physics was shaped as a subject appropriate to and even necessary for female students in an increasingly technological age. In this specially tailored version of introductory physics, female students learned how to be scientifically informed consumers who fearlessly accepted and appreciated new technologies. The courses also had the added benefit of boosting physics enrollment numbers.

The women in household physics classes were not simply victims of corporate manipulation. They learned skills that were not only useful at home but could lead to positions in industry. Many local utilities and larger consumer products companies such as Corning, Proctor & Gamble, and Kraft hired women into what were called home-service departments, where they worked as technology consultants, equipment testers, or consumer liaisons.[11]

Present-day readers, however, can take a lesson from this historical episode. Despite the positive outcomes the courses had for the careers of many individuals, they also derailed many women's education in physics—or at the very least, sidetracked them into a field that had little likelihood of further graduate study. One woman complained in the 1939 Radcliffe College yearbook that "weeks were spent in freeing Dr. Stehn from a suspected inhibition toward teaching *Thermodynamics* to the species whom he felt could use to much better advantage *The Physics of the Vacuum Cleaner*." Her comment suggested that the existence of household physics made other areas of inquiry seem inappropriate for or beyond the reach of female students.[12]

It might be tempting, given the continued gender disparity in physics, to try to make the subject matter appeal to women. But the solution is most certainly not to make physics "pink," as the European Union Commission did in their ill-conceived teaser video for the 2012 campaign "Science: It's a Girl Thing!"[13] Rather, students of all genders ought to be encouraged to pursue physics in any of the field's many facets. In physics education, as in all aspects of life, it is better to appeal to people as individuals rather than as stereotypes.

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