Cold War Classroom:

Teaching Quantum Theory in Postwar American Physics

8.225 / STS.042, Physics in the 20th Century
Professor David Kaiser, 4 November 2020
1. “Big Science”

2. The “Scientific Manpower” Bubble

3. Training Quantum Mechanics
“Big Science”

1949: 96% of funds for academic physics research from military
1954: 98% of funds for academic physics research from military

Big Budgets

1938 – 1953: 25x increase

P. Forman, 1987
"Big Science"

MIT’s 350 MeV synchrotron, mid-1950s
By 1952, physicists began to joke that a new particle seemed to be discovered every month.
“Big Science”

Big Enrollments

Prof. Anthony French teaching physics at MIT in 26-100, 1964

© MIT Museum. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/
Physics Ph.D.s in the US
Who was filling those seats?

Prof. Anthony French teaching physics at MIT in 26-100, 1964
Harvard letter of recommendation for a physics PhD student applying for a position at the AEC’s Argonne National Laboratory, 1954: the student had a traditional-sounding Japanese last name, so the letter-writer emphasized that the student was actually a US citizen from Honolulu and a US veteran of World War II.

Naval Academy (Annapolis) job ad for a new physics faculty member, 1953: only those who were “white, male, and an American citizen” were eligible to apply.

February 1950 notes on prospective faculty candidates, Berkeley physics department: “Medium height, dark, rather handsome Jewish type,” whereas a different candidate with “Jewish features” was “perhaps slightly forward in manner.”

Berkeley’s physics department chair, 1955: the department had “practically no minority group problems. So far as race is concerned, we have never yet had a negro graduate student in the department, hence that particular problem [sic] has never arisen.”
Throughout the 1930s, women had accounted for about 16% of the physics B.A. degrees earned each year in the US. During the 1950s, the proportion fell to 4%. Meanwhile, the proportion of women earning PhDs in physics dropped from 4% to 2% each year.

“The married [physics graduate] student’s wife expects him home every evening at five or five-thirty. Now the laboratories are dark at night.” — Interview with psychologist Ann Roe, 1950

John Slater (MIT): “Present students find it harder to settle down to work. Wives and babies take up a lot of time that my generation put into physics. The wives, it is true, help to type their husbands’ theses, but in the older days the necessity of doing this ourselves made us learn typing.” — Physics Today 1969
At Harvard during the 1950s, the Physics Department included between 3 and 7 women PhD students each year (out of 100 PhD students). The women were registered through the “Radcliffe Graduate School,” even though Radcliffe did not have its own physics department. Once enrolled, their files were put in a “Radcliffe” pile—so they sometimes missed notifications like the time and place for final exams.

1962 AIP data: women who did pursue careers in physics averaged **30% lower earnings** than men who had achieved the same level of education in the field.

Physics Dept Jr. Faculty Skit, Univ. Illinois, 1963: Men should submit their credit ratings on admissions forms, while “girls could submit photos in bathing suits, and give critical measurements.”

Cold War “big science” meant a *certain kind* of booming enrollments—and a colossal, collective failure of the imagination.
Questions?
“Manpower”

“In a time of national emergency, this country would think nothing of spending a million dollars to survey, develop, and conserve a short commodity like natural rubber or tin. Highly trained and able human resources, viewed as a commodity, are far more important.”

H. A. Barton, AIP, 1948

“Scientific manpower” was a “war commodity,” a “tool of war,” and a “major war asset,” and hence needed to be “stockpiled” and “rationed.”

H. D. Smyth, 1950
If $N$ nuclear physicists were “willing, able, and eager to use particle accelerators, and on average five such men per accelerator is an effective team,” then the AEC should build $N/5$ accelerators, or two per year for as long as “the international situation remains roughly as at present.”

*AEC memo, July 1951*

In 1948 the AEC *overruled* its GAC, which had argued that only one GeV particle accelerator was necessary, scientifically. The AEC built *two* to avoid hurting physicists’ “morale.”
If $N$ nuclear physicists were “willing, able, and eager to use particle accelerators, and on average five such men per accelerator is an effective team,” then the AEC should build $N/5$ accelerators, or two per year for as long as “the international situation remains roughly as at present.”

*AEC memo, July 1951*

1953: 75% of physics PhDs who completed their degrees with AEC support took jobs with the AEC.
The Cold War Bubble

![Graph showing the number of Physics PhDs per year from 1900 to 1980, with a spike in the mid-1980s labeled as the "Nasdaq since 1985". The graph indicates a peak in 2000.](image)
Speculative Bubbles

- Tulip craze, 1630s
- South Sea Bubble, 1720
- Tech stocks, 1990s
- Housing prices, 2000s

“a situation in which temporarily high prices are sustained largely by investors’ enthusiasm rather than by consistent estimation of real value.”  
Robert Shiller

Roles of *hype, amplification, and feedback loops.*
Assessing the Soviet Threat


Alexander Korol, *Soviet Education for Science and Technology* (1957)


DeWitt: “an indefatigable digger”; Korol: “fastidious”
“Perplexities and Pitfalls”

Both DeWitt and Korol warned against getting lost in the “numbers game”:

- large fraction of Soviet engineers worked in administration, not R&D
- extreme specialization
- standards jimmied to fit “production quotas” of 5-year plans
- extension and correspondence students inflating the ranks: 1/3 in 1955, >1/2 in 1960.

**nonferrous metals metallurgy**

1. copper and alloys;
2. precious metals refining;
3. …

11.
Enrollment Patterns

Korol refused to tabulate enrollment data side by side, to avoid “unwarranted implications.” DeWitt did so only after emphasizing all the caveats. He found:

### Annual Degrees in Higher Education

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>USSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>full-time students</td>
<td>3 :</td>
<td>1</td>
</tr>
<tr>
<td>full + extension</td>
<td>4 :</td>
<td>3</td>
</tr>
<tr>
<td>science and technology</td>
<td>25%</td>
<td>75%</td>
</tr>
</tbody>
</table>

The Soviets were graduating 2-3 times more students per year in engineering and applied sciences than the US.
Hype: “Two to Three Times…”

Russia Is Overtaking U.S. In Training of Technicians

Red Technical Graduates Are Double Those in U. S.

Eisenhower and Sputnik images are in the public domain.

…and then came Sputnik
Amplification

I. I. Rabi, chair of PSAC: Urged Eisenhower to use Sputnik as a pretext for closing the “manpower gap.”

Elmer Hutchisson, director of AIP: “an almost unprecedented opportunity” to “influence public opinion greatly.”

Hans Bethe, past president of APS: repeated DeWitt’s ratio without knowing from whence it came or how it had been computed.

Eager press: count up number of hours spent on physics in US and USSR high schools.
Feedback Loop


First 4 years: 7k graduate fellowships; 500k undergrads.

Plus block grants and added incentives to states to increase enrollments. Sputnik scare had been used as a “Trojan Horse.”

NDEA’s proponents “were willing to strain the evidence to establish a new policy.”

All aid was restricted to “defense” fields: science, math, engineering, and area studies.
Lies, Damn Lies, and Statistics

Even aside from DeWitt’s and Korol’s caveats — uneven quality, severe specialization, and inflation from extension and correspondence students — the numbers themselves deserved a closer look.

DeWitt: “engineering and applied sciences” = engineering, agriculture, and health ➔ “2 to 3 times”

If drop agriculture and health and include science and math, the Soviet lead fell by a factor of 10.
The Bubble Bursts

AIP Job Placement Registries

<table>
<thead>
<tr>
<th>Year</th>
<th>Students registered</th>
<th>Jobs on offer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1963</td>
<td>449</td>
<td>514</td>
</tr>
<tr>
<td>1968</td>
<td>989</td>
<td>253</td>
</tr>
<tr>
<td>1970</td>
<td>1010</td>
<td>63</td>
</tr>
<tr>
<td>1971</td>
<td>1053</td>
<td>53</td>
</tr>
</tbody>
</table>

Images © sources unknown. All rights reserved. This content is excluded from our Creative Commons license. For more information, see https://ocw.mit.edu/help/faq-fair-use/
Questions?
Bubbles and the World of Ideas

Stacks of the *Physical Review* by decade, 1890s–1970s
“The General Epistemological Lesson...”
Quantum Americans

Caltech oral exams, 1930s:

- measurement problem and the role of the observer
- uncertainty principle and the nature of physical explanation

Lecture notes, exams, textbooks, book reviews…
Philosophy Disappears

"Enough with this musty atavistic to-do about position and momentum…"

Feshbach, 1962

"Shut up and calculate!"

Book reviews: “avoids philosophical discussion”; “omits distracting, philosophically tainted questions”…

Caltech oral exams, 1950s:

- “the effort invested in analysis of paradoxes and queer logical points was of no use in the exam.”

- best advice: “memorize” and “rehearse” stock problems (“the usual spiel”).

General exams elsewhere: interpretive essay questions (1930s-40s) replaced by coterie of standard calculations (1950s).
Accounting for the Shift

• *Were the puzzles and paradoxes resolved?*

   No: still subject of active research outside the US.

• *Did war work turn US physicists into pragmatists?*

   Not entirely: Nordheim, Epstein, Hill, …
• **Changing patronage or employment demands?**

No correlation between the style of a department’s QM courses and where that department’s students got jobs.

• **Pedagogical pressures?**

Compare across US classrooms at the same time; and compare US and international textbooks over long time.
Class Size and Teaching Style

Graduate-level QM courses in US, mid-1950s

“philosophical” classrooms

enrollment: $12.7 \pm 5.7$

interpretive material: $12.8 \pm 1.4\%$

“pragmatic” classrooms

enrollment: $39.3 \pm 13.4$

interpretive material: $2.6 \pm 1.5\%$

Above © source unknown. Left © Samuel Goudsmit / AIP Emilio Segrè Visual Archives. All rights reserved. This content is excluded from our Creative Commons license. For more information, see [https://ocw.mit.edu/help/faq-fair-use/](https://ocw.mit.edu/help/faq-fair-use/)
Essays and Algebra

US physicists published 33 graduate-level QM textbooks during 1949-78, containing 6,261 problems.
Bubble Physics

*Berkeley case*, mid-1950s. Research on foundations of quantum field theory was deemed pedagogically inappropriate:

“It is not the sort of work that can readily be used for Ph.D. theses. ... Hence it seemed to our committee that [he] was not carrying his fair share of the load of graduate student research. ... It was therefore felt that he would not be particularly valuable to us since we have a very large number of graduate students who must be guided to the Ph.D. degree.”
Entering Graduate-Student Cohort, Stanford Physics Department

**Stanford, 1972:** new informal seminar on “speculations in physics.”

- **True-False General Exams**
- **Generals: 40% Essay Questions**
International Trends

**Canada, UK**: Similar enrollment pattern; similar QM textbooks.

**W. Europe**: Little enrollment pressure after the war. Postwar QM textbooks still included long sections on philosophy. (US reviewers: “excessive,” “overdone.”) Few books included any problems at all; those that did averaged *three times* the proportion of short-answer problems as US books.
“Physicists pretended a fundamental character to their work that it scarcely had. [Their work retained] merely instrumental significance to their military patrons.”

Left unexplained is how patronage might shape the world of ideas. The gears mesh in institutions and infrastructure.