What Accounts for Japan's Success in Science Education?

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Japanese science education is more successful than its American counterpart in both quality and quantity. In Japan, more students take avanced science courses, the curriculum to be mastered by all is more demanding, and the average cognitive achievement of students and the level of literacy of the population are higher than in the United States. Some of this success is due to the effectiveness of Japanese elementary and secondary education overall, as well as to specific features of Japanese science education.

Institutions

Education in Japan is highly centralized through the Ministry of Education, the *Mombushō*, which controls textbook approval, school accreditation, teachers' salaries, educational subsidies, and the all–important course of study. The first nine years of Japanese education are compulsory and are completed by nearly all students. Ninety–four percent attend high school, while 37 percent go on to college or university.[1] The minimum course content is specified in detail all the way through high school, and all students are expected to achieve equal mastery. The course of study sets a very high minimum, internationally speaking.

The model of learning used by the Japanese is "hard work plus time equals learning." Ability is viewed as less important than hard work. The teachers' union, *Nikkyōso*, acts as a counterweight to the Ministry of Education, and each quells the excesses of the other. As the articulator of progressive values, *Nikkyōso* has stressed "whole person education," science for understanding, the creative use of science, and the impact of science upon the

Japan excels because of a demanding curriculum, the number of hours devoted to the subject, the examination system, and the crucial role of the home.

world. It has also championed equality of educational opportunity, compensatory aid, and minority rights, and has been hostile to tracking, including vocational education.[2]

In Japan, attendance at National Universities or the best private universities is necessary for climbing to the top of the leadership ladder in business or the highly respected civil service; job entry and advancement are severely limited for those whose low scores on merit exams preclude education at an elite university. Since attendance at the right university is fundamental to success, "examination hell" spreads down into those high schools with a reputation for fostering success on examinations. Parents with larger financial resources are in a better position, therefore, to aid their children than are those of more modest means, as is exemplified by *rōnin*, students cramming for a year in order to retake entrance examinations, and *juku*, after-school cram schools, each of which offers its own curriculum.[3] Moreover, while there is equality of opportunity across gender, equality of results extends only into junior high.[4]

Classroom Procedures and Moral Education

Equalitarianism and the examination system have interesting effects upon the classroom. Since neither class rank nor grades are considered for college entrance, competition is not with one's classmates. This leads to a warm, familistic classroom environment, particularly at compulsory levels.

Moral education plays a part in maintaining classroom order. The formal moral education curriculum deals primarily with interpersonal ethical problems, dignity, and self-respect, while such duties as keeping the halls and classrooms clean teach respect for the building and grounds. One key to the reduced "babysitting" responsibilities of Japanese teachers is recognition that time wasted in the classroom hinders the capacity of the group from doing well on exams. Thus wasting time hurts all, instead of being neutral as it is in the U.S. where students compete against each other. In upper primary grades, Japanese classrooms are well-ordered, primarily due to the internal control students develop, not to the vigilance of the teacher. Family emphasis on the importance of school to later life is also important in keeping classroom order.

Family and Education

Japanese families are strongly involved in education. The International Association for the Evaluation of Educational Achievement (IEA) study found that family background played a moderate role, while home processes were very important in differences in science learning.[5]

Congruity between home and school aids in the cooperative effort to foster learning. In my studies, I have found that a student's perception of his or her parents' and siblings' interest in science is a strong predictor of his or her own. Furthermore, in the IEA study the association between liking science and achievement in science was highest in Japan.[6] Although home commitment to science is important in both countries, the fitting together of home and school is better in Japan than in the U.S.[7]

Science Curriculum: Quantity

Several features of Japanese science education are responsible for its success: students get off to an early start; science is required throughout primary school and is highly experiential or lab-oriented. It is estimated that one-third of the time in primary school is spent this way. The emphasis is upon developing positive feelings for and on encouraging an intuitive grasp of science. During junior high school and especially in high school as the entrance exams loom, the curriculum becomes more test- and teacher-oriented. The fraction of time in the lab shrinks to about one-eighth of total time in class.[8]

Science and mathematics play a large role in the general curriculum as set by the Ministry of Education. Science and arithmetic, which both begin in first grade in Japan, occupy 27 percent of the total primary school curriculum (1,569 45-minute periods in grades 1–6). In junior high school, the relative fraction of science and mathematics (23.3 percent) is a similarly large portion of the whole, since there are elective activities (11.1 percent), some of which may be science (see Figure 1).[9] In junior high, 350 50-minute periods of science are

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Figure 1. Percent of Japanese School Curriculum in Subject Areas, by Grade Level

	Grades 1–2	3–4	5–6	1–6	7–9	1–9
Science and arithmetic	25.5 (13)	28.1 (16)	27.6 (16)	27.1 (45)	23.3 (21)	25.8 (66)
Japanese language	31.4 (16)	28.1 (16)	20.7 (12)	26.5 (44)	14.4 (13)	22.3 (57)
Arts, music, home economics	15.7 (8)	14.0 (8)	20.7 (12)	16.9 (28)	18.9 (17)	17.6 (45)
Phys. ed. and special activities	15.7 (8)	15.8 (9)	17.2 (10)	16.3 (27)	16.7 (15)	16.4 (42)
Social studies and moral education	11.8 (6)	14.0 (8)	13.8 (8)	13.3 (22)	15.6 (14)	14.1 (36)
Elective subjects					11.1 (10)	3.9 (10)
Total	100.1 (51)	100 (57)	100 (58)	100.1 (166)	100 (90)	100.1 (256)

Source: Adapted from Mombushō (see Footnote 1).
Notes: The two-year grouping of primary grades corresponds to Japanese convention; the numbers in parentheses are the credits in that area.

required. The total for grades one to nine, then, is 908 periods (10.2 percent) of science and 1,396 periods (15.6 percent) of arithmetic and mathematics out of 8,935 total (see Figure 2).

Though high school science is less readily measured because of more electives, a liberal estimate of textbooks produced in 1979 suggests that the average student in Japan takes 1¼ science courses per year in three years of high school.[10] Hence, in terms of volume, Japanese students take more science and mathematics than their American counterparts. In addition, because 94 percent of Japanese go to high school, this results in a more scientifically literate public.

Science Curriculum: Quality

In terms of quality, two measures indicate superior performance in Japanese science education. First, the Japanese did far better on the IEA science exams than did students in the U.S. The Japanese were ranked first of 19 for 10– and 14–year–olds in overall science achievement while the U.S. ranked 4th for 10–year–olds and 7th for 14–year–olds (and 14th of 18 countries for senior high school students; Japan did not participate). The Japanese did particularly well on higher mental processes.[11]

A second measure of curriculum quality is the volume of material mastered and its sophistication. The "opportunity to learn" index for Japanese junior high students on the IEA study ranked first (they had the greatest topical coverage,[12] inferentially suggesting a higher quality). Furthermore, the topics covered in Japan are more advanced.[13] In mathematics, the basic high school course to be mastered by all students includes not only second year algebra but also plain and solid geometry, elementary statistics, and exposure to calculus (differentiation and integration); science courses in junior high school cover topics reserved in the U.S. for high school.[14]

Japanese science courses typically integrate mathematics more than most U.S. courses. For example, the advanced physics course presupposes calculus. Topics in advanced mathematics include limits, differential equations, statistical inference, and operations research. Advanced science courses resemble college courses in the U.S. in terms of mathematical sophistication and topical coverage. Under the old curriculum approximately one–fifth of Japanese students took advanced courses in physics, chemistry, biology, or earth science, whereas only about 2 percent of American students have taken a calculus course in high school, let alone a science course that presupposes exposure to calculus.[15]

Teacher Training and Status

At the university level, approximately the same fraction of students in Japan and the U.S. major in natural science (3.1 percent in Japan); engineering is a more important major in Japan (19.7 percent of university enrollment plus technical and junior colleges).[16]

Well–trained science teachers are also part of Japan's success in teaching science. The training of science teachers is oriented primarily toward science courses, though many education courses are offered. Much teacher training takes place at the university level. National Universities, which are the most selective of the college–level institutions, train most of the science teachers, while the Science Education Promotion Law aids the effort to recruit them by supplementing teacher salaries.[17]

Relative to other occupations, science teacher salaries in Japan rank higher than in the U.S. Furthermore, their status is much higher, and their conditions of work are generally better than in the U.S.[18]

Finally, the IEA study found Japanese science teachers to be more professional than their U.S. counterparts (attendance at meetings, professional association membership).[19] The professionalism and quality of Japanese science teachers is further aided by 200 Science Education Centers oriented primarily toward inservice training of teachers and the encouragement of research in science education.[20]

Science Outside School

Young people in Japan also have opportunities to learn about science outside of school. For example, the monthly circulation of one magazine, *Kagaku No Zasshi* (*Science Magazine*) with its association "kits" is 5,670,000—nearly a million per grade per month, reaching about half of the households at each grade level in primary school.[21] In addition, both commercial and public television in Japan broadcast scientifically more advanced programs than in the U.S. This is because Japan has a more knowledgeable audience for such programming.

Overview and Application

In sum, perhaps the most important features promoting science learning in Japan are the demanding curriculum, the amount of time spent studying science, the examination system, and the crucial role of the home in developing commitment to learning science. Teacher professionalism is also important, including commitment to equality of educational opportunity.

What are the possible adoptions and the limits to adoption in the United States? Two limits are provided by a strong mistrust of centralization and the lack of widespread respect for learning (anti–intellectualism?) in the U.S. Further, how committed are we to full equality of educational opportunity? Could we institute a meritocratic examination system with financial support for all those who need it? Will the economically privileged pay so that all schools are equally good at the compulsory levels or allow merit to be the sole judge of entrance? Are family and youth motivated to support such a massive involvement of time and energy?

Among the possible adoptions are heightened family involvement in science learning, primary school science, primary school science magazines, science education centers, stronger support for science teaching (including salary and status), a lessened babysitting role for teachers, and support for research on science learning. Heightened concern with equal mastery by all and a more demanding curriculum might be adopted, and perhaps a system of merit examinations encouraging equality of opportunity might be instituted. Surely the goal of greater science literacy for all—student, parent, citizen, and decision maker—is a worthy goal.□

Figure 2. Number of Periods in Japanese Curriculum by Subject Area

	Grade Levels		
	1–6 (%)	7–9 (%)	1–9 (%)
Science	558 (9.6)	350 (11.1)	908 (10.2)
Arithmetic/mathematics	1,011 (A) (17.5)	385 (M) (12.2)	1,396 (15.6)
Science and arithmetic	1,569 (27.1)	735 (23.3)	2,304 (25.8)
Japanese language	1,532	455	1,987
Arts, music, home economics	976	595	1,571
Phys. ed. and special activities	941	525	1,466
Social studies and moral educ.	767	490	1,257
Elective subjects	—	350	350
Total	5,785 (45 min. periods)	3,150 (50 min. periods)	8,935

Source: Adapted from Mombushō (see Footnote 1).

[1]Mombushō, *Mombushō* 17 (1981); for this and other statistical references see also Mombushō, *Mobovokeiyōran* (1979); National Institute for Educational Research (NIER), "Basic Facts and Figures About the Educational System in Japan," (1982); and Kay Michael Troost (1983 forthcoming).

[2]For an extended treatment from a pro–union source, see William K. Cummings, *Education and Equality in Japan* (Princeton, N.J.: Princeton, 1980), especially Chapter 3.

[3]For more on school and classroom procedures see William K. Cummings, op. cit.

[4]Thomas P. Rohlen, "The Juku Phenomenon: An Exploratory Essay," *Journal of Japanese Studies* 6 (1980): 207–242.

[5]Kay Michael Troost, "Educational Equality of Opportunity in Japan: Family Background and Gender," unpublished paper, NIER, July 1983, Toyko; see also Troost, op. cit., 1983.

[6]L. C. Comber and John Keeves, *Science Education in Nineteen Countries* (New York: Halstead, 1973): 217, 245, 258–263.

[7]Comber and Keeves, ibid., p. 259.

[8]Kay Michael Troost, "Pathways to Learning: The Central Role of the Home Environment," *Hiroshima Forum for Psychology* 7 (1980): 35–46.

[9]Christie Kiefer, "The Psychological Interdependence of Family, School and Bureaucracy in Japan," in *Japanese Culture and Behavior*, eds. Takie Sugiyama Lebra and William P. Lebra (Honolulu: University Press of Hawaii, 1974), pp. 342–356.

[10]Masao Mikaye, "National Science Curriculum Case Studies," unpublished paper, NIER, Toyko, 1981, pp. 12, 14.

[11]Adapted from Mombushō, op cit (1981), p. 22. See also Mikaye, op cit (1981), p. 6, and NIER, op. cit., pp. 16–17.

[12]Hideo Ohashi, "Evaluating Curriculum Change in Japan," *Journal of Science Education in Japan* 4 (1980): 129–138.

[13]Comber and Keeves, op. cit., p. 159.

[14]Comber and Keeves, op. cit., p. 161.

[15]For a more extensive treatment of the science curriculum, see Troost, op. cit., 1983.

[16]Troost, 1983, ibid.; see also the English language version of the course of study: Mombushō (1976, 1980, 1982).

[17]Clifford Adelman, "Devaluation, Diffusion, and the College Connection: A Study of High School Transcripts, 1964–1981," (National Institute of Education, 1982).

[18]Mombushō, op. cit., 1981, p. 16.

[19]Ronald S. Anderson, *Education in Japan* (Washington, D.C.: U.S. Government Printing Office, 1975): 166.

[20]Troost, op. cit., 1983, p. 29; and Cummings, op. cit., p. 255.

[21]Comber and Keeves, op. cit., pp. 82–83.

[22]Mikaye, op. cit.; and Anderson, op. cit.

[23]Troost, op. cit., 1983, p. 33; based upon correspondence with the publisher, Gakken, March 1982.