How Knowledge Moves

Writing the Transnational History of Science and Technology

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CHAPTER ELEVEN

The Transnational Physical Science Study Committee

The Evolving Nation in the World of Science and Education (1945–1975)

Josep Simon

In 1964 Robert I. Hulsizer became director of the Science Teaching Center of the Massachusetts Institute of Technology, after more than a decade at the University of Illinois and after playing a key role in the development of the Physical Science Study Committee (PSSC). He had graduated as a physicist during World War II, worked at the Radiation Laboratory, and received his doctorate at MIT. On coming back to MIT he advocated the preparation of a new freshman physics course, which he characterized as "like trying to describe an evolving nation. It exists and therefore can be characterized at its present state. Yet one's view of the course is a mixture of past tradition, past and present hopes and partial realization of these hopes."[1]

Another major actor in the making of that MIT course, Anthony P. French,[2] emphasized in his proposal MIT's "well-developed tradition of strong and respected courses in introductory physics." This tradition had started in the 1930s with Nathaniel Frank's courses, followed by Francis Sears's textbooks and Jerrold Zacharias and Francis Friedman's PSSC. The new course would be another step in that tradition, for the service of MIT and the nation. French's narrative was an essentially local and national one radiating out from MIT and the United States to the rest of the world.[3]

The PSSC, the major project to which Hulsizer's and French's experiences and imaginaries refer, developed a new physics course for American high schools between 1956 and 1960. The PSSC was supported by grants from the National Science Foundation (NSF), the Sloan Foundation, and the Ford Foundation, with headquarters at MIT and the University of Illinois. It was a large and complex project that used a military-industrial management model, a major novelty in the production of teaching materials. In 1960 the first edition of the PSSC's *Physics* was published. A few years later, almost half of the nation's schools were using PSSC materials, and its textbook had been translated into a dozen languages.[4]

French and Hulsizer's testimonies mark the PSSC as a major and recent milestone in an "evolving nation," which was further evolving through the production of new courses at MIT. In some of the pedagogical landmarks, mentioned by French, the goals and approaches localized in a particular institution (MIT) could be projected onto the whole nation. In other cases, such as the PSSC, there was a larger interaction and integration of aims and methods from different institutions and communities of practitioners in order to produce a pedagogical package able to build the nation and eventually to go beyond it. Indeed, this project, which sought to collapse US science education into one single national course able to boost the production of scientists, managed to spread its impulse of educational reform to Europe, Latin America, Asia, and Oceania. Today, the PSSC is seen by science educators as a common heritage of science education worldwide.[5]

The enthusiasm for physics teaching and for developing an exportable physics course that could spread throughout the world was in tune with the vision of MIT being advocated at the time by Gordon Brown, MIT's dean of engineering. For Brown MIT was at the intersection between the past, present, and future. It had matured into a major center for engineering education, and its educational programs were ripe for exporting nationally and internationally. They were of a piece with the programs being advocated by MIT's Ford Foundation–funded Center for International Studies directed by Max Millikan and Walt Rostow, who would promote modernization theory and nation building as tools of US foreign policy around the world.[6] Hulsizer and French were imbued with that same MIT "idea." Their characterization of the MIT freshman physics course coupled the development of pedagogy and of the nation, and it located its force in both the continuation of tradition and the imagination of new configurations. Theirs is a powerful illustration of the strong connections between science education and the nation, and the national imaginaries of Cold War physicists, which fit perfectly with classic historical research on the nation and nationalism.[7]

Nationalism has not always characterized the writing of US national history. Historians of nineteenth-century American science studied the making of national institutions, but they also paid attention to the American observation and appropriation of the German, British, and French experiences.[8] In contrast, analogous work for the Cold War period favors the view that after World War II, US science and education had grown to become autonomous.[9] Despite the global importance of American science and science education in this period, it is worth asking if these facts constitute in themselves a sine qua non condition for the congruence of our historiographical perspectives with the national unit.[10] Undeniably, a nation exists with regard to other nations, and as a state, with regard to other states.[11] Educational reform is particularly illustrative of this, thanks to its cross-national tradition, since all types of nation-states (nonhegemonic and hegemonic) have commonly looked abroad for relevant experiences before undertaking substantial changes in education practices at home.[12] The PSSC illustrates well this dynamic in national and international affairs.

Decades ago, one of the prime movers in the development of transnational history was the urge to open American history to the world by overcoming its traditional exceptionalism.[13] Transnational perspectives could contribute to shaking the foundations of historical characterizations that were insufficient but had long held sway. This chapter takes the PSSC as an object allowing us to unravel the historical and historiographical elements that may justify narrating the history of US science and education from a local, national, international, or transnational perspective. Central to my approach is the discussion of the advantages and shortcomings of each of these perspectives.

Accordingly, I provide a big picture of the PSSC and its contemporary history in the United States and abroad. The first section of the chapter examines the making of the PSSC from a local and national perspective. The second section deals with the committee's internationalization. In the final section I discuss the findings presented in the previous two sections and the potential of applying a transnational approach to this case study.

The American PSSC

The PSSC was born first as a local and personal initiative, but it rapidly expanded into a collective effort that assembled a large number of universities, colleges, and schools, physics professors and teachers, and educational researchers, technicians, managers, and consultants. It befitted the "signs of the times" and found major support in institutions such as the NSF, the American Institute of Physics (AIP), and the American Association of Physics Teachers (AAPT), which were developing programs to tackle the same problems. In this section I want to stress that although the PSSC was developed on US soil, its national (American) character was not a given natural quality but the result of a particular geopolitical infrastructure and the agency of certain project members.

Since the early decades of the twentieth century, some academic physicists in the United States had expressed dissatisfaction with the school curriculum, textbooks, and teacher training, emphasized the need to control and homogenize college requirements, and remarked on the tension between training physicists and training citizens and on the excessive reliance on European physics professors.[14] The decentralized nature of the American school system and the lack of interest among most university physicists had prevented any large-scale reform.[15]

By the mid-1950s, however, a series of events had merged to promote a widely generalized opinion in the US Congress that the country required a large investment in school science reform. The large number of specialized conferences held since the early 1950s and the National Defense Education Act of 1958 were key elements in this movement.[16] The newly created NSF (1950) managed to become the favored institution to tackle the problem of scientific manpower.[17]

Several initiatives were launched to improve physics teaching. In March 1956 Jerrold Zacharias, an MIT physicist, sent a memo titled "Movie Aids for Teaching Physics in High Schools" to the president of his institution. His project was couched in the language of atomic physics; it focused on experiment and film, and its pretension was mainly local and personal.[18] In parallel, and beginning in 1955, a series of conferences supported by the AAPT, the AIP, and other agencies had also begun to tackle the main problems of physics teaching.[19] A central actor in these conferences was Walter C. Michels of Bryn Mawr College, AAPT's president-elect. He chaired a Joint Committee on Teaching Materials for High School Physics established by the AIP, the AAPT, and the National Science Teachers Association.[20] From 1960 Michels also chaired the AIP-AAPT Commission of College Physics, which developed a national survey of physics teaching programs with the aim of improving them. As national federations of physicists' societies and national organizations composed of regional sections in each US state, the AIP and AAPT had both the legitimacy and the capacity to conduct such an endeavor. MIT physicists were manifestly absent from these conferences,[21] a fact which limits the role that the historiography has traditionally given to MIT and its professors in the making of national science education and suggests instead the agency of other institutional and individual actors in this process.

A week after the 1956 AIP-AAPT Conference on Physics in Education, Zacharias sent a proposal to the NSF.[22] He was able to receive the support of MIT's president and chancellor and to use their connections and his war acquaintances to ensure the success of the application.[23] By September 1956 the project had taken its final name: Physical Science Study Committee. The Committee expressed interest in working with the Educational Testing Service (ETS)[24] in the development of its materials and the design of examination tools.[25]

The PSSC rapidly expanded through the incorporation of members from Cornell, Caltech, Illinois, and Bell Laboratories.[26] The team eventually included several hundred physicists, high school teachers, instrument makers, filmmakers, photographers, editors, typists, and educational test designers. To deal with the daily requirements of the project, Educational Services Incorporated (ESI), a nonprofit company, was created with its own staff.

By the late 1950s the PSSC preliminary materials had been tried in schools in Pennsylvania (three), Massachusetts (two), New Hampshire (one), New York (one), and Illinois (one).[27] Without undermining the importance of the official leaders of the project, Jerrold Zacharias and Francis Friedman at MIT, I should mention two other actors who, from a national perspective, had a major role in the making of the PSSC. Their relevance has often been downplayed in official accounts of the PSSC project, which has been characterized by a national pretension but a local (MIT) narrative.[28]

One of them was Walter Michels, whom we met a moment ago. Michels played a major role in the coordination and supervision of the production of PSSC materials, especially with regard to their testing in pilot schools. Pennsylvania contributed three of the eight pilot schools and Michels's work was fundamental in this context. Furthermore, he had a knowledge of, and contact with, the nation's physics-teaching community, which other members of the PSSC did not possess. The physicists leading the project at MIT were not part of that community, nor did they demonstrate any particular interest in getting to know it.

The other major actor was the group at the University of Illinois, which led the production of the PSSC Teacher's Guide and the supervision of evaluation in the pilot schools. The University of Illinois had had a laboratory high school since the 1920s, developing close collaboration between teachers and university professors in science and education (which was atypical). It hosted the earliest project of science curriculum reform in the United States after World War II: the University of Illinois Committee on School Mathematics (1951–1961), funded by the US Office of Education, the NSF, and the Carnegie Corporation.[29] Some of its members subsequently joined the PSSC. As we saw at the outset of this chapter, before joining MIT, Hulsizer was a professor at the University of Illinois and a member of the PSSC group there. Not only his previous MIT training but especially his experience at Illinois with the day-to-day operations of the PSSC arguably played a major role in his subsequent hiring as director of MIT's Science Teaching Center.

Michels's and Hulsizer's actions at their institutions, working together and networking with schools, colleges, and teachers in Pennsylvania and Illinois, and extending beyond to a large number of institutions and practitioners in other US states (where Michels was very effective), really did contribute to shaping the nation through science education reform. If the PSSC became an "evolving nation" able to map a large amount of US political and educational territory, it was not exclusively because of the political power and scientific prestige of MIT physicists but especially because of the agency of other actors such as the aforementioned.

By 1958 eight teachers had been using preliminary versions of the PSSC course with around three hundred students. Summer training programs were offered by five universities for around three hundred teachers. By 1959 there were more than 10,000 students using the trial materials. The ESI bulletin that year included a US map displaying this expansive distribution.[30] In 1965 there were around 5,000 teachers and 200,000 students using the PSSC program of study, accounting for almost 50 percent of the secondary school students enrolled in high school physics courses in the United States.[31]

In parallel, regional groups met to study the PSSC materials. They emerged in all the states except Alabama, Arkansas, Hawaii, Kentucky, Mississippi, Montana, Nevada, New Mexico, North and South Dakota, Tennessee, Utah, Vermont, and Wyoming. Some of these meetings were organized around further state divisions or large metropolitan areas such as New York, San Francisco, Los Angeles, Chicago, San Diego, Philadelphia, and Boston.[32]

The largest increase in the number of schools using PSSC materials occurred along the East and West Coasts, in the Midwest (then called the North Central region), and especially around urban areas. The rest of the country—with the exception of Florida—did not use PSSC materials and accounted for roughly half of the nation's physics high school population. Some of these schools expressed their reluctance to adopt PSSC courses and their preference for other projects of curriculum development such as Harvard's Project Physics.[33]

During the early implementation of the PSSC course in American schools, the Committee had to negotiate with the College Entrance Examination Board (CEEB) to create a special achievement test for those who had followed the course. The CEEB was founded in 1899 by twelve eastern colleges as a way to regulate and rationalize the variety of examinations applied by colleges to select their students.[34] During the first half of the twentieth century, the CEEB expanded to win a national coverage.[35] In 1926 it began administering the Scholastic Aptitude Test (SAT). After World War II, the CEEB tests were published by ETS. The development of tests with regional or national aspirations in the United States had been especially boosted by the two world wars, to ensure that army recruits met a minimum educational standard. The tests were soon adapted to school and college management. The implementation of these test programs generated heated debates because they could lead to standardization of curricula and interference with the states' administration, and there was no consensus as to their purpose and value.[36] All the same, by 1966 around 800 colleges and 250 scholarship programs used CEEB tests in their admissions processes. This did not deter the PSSC team, who argued that the standard CEEB tests were designed to assess a traditional physics course and so were inappropriate for their students. To solve the problem for future school years, they worked with the CEEB and ETS to produce a unified physics test suitable for all students.[37]

We see then that to produce an American physics course, the PSSC had to rely on infrastructure and collaboration provided by other initiatives which were also aiming at building the US nation by standardizing evaluation in its schools and universities. ETS had been involved in the PSSC since its inception.[38] ETS tests were not only an end product but also a fundamental technique to shape the PSSC course, since the tests were seen as an objective technology to measure the course's excellence. The tests were also an advertising tool to promote the idea of the pedagogical superiority of the PSSC option, favoring its adoption over other courses in the nation's schools.[39]

The leaders of the PSSC did not all agree on what its national role should be. Although it aimed at targeting the largest number of American schools, some of the PSSC founding members had more restrictive and elitist views: "The course should be directed to the top 25 per cent of high school students with the aims of inducing more of them to move into advanced work and of creating in the others a cultural climate favorable to scientific activity."[40] Its pursuit of national supremacy was also challenged by other scientists and educators, who had different views on what physics teaching and American education should be. Many suggested the worth of more humility or denounced the presumptuousness of the PSSC endeavor and its leaders.[41] Moreover, there were other competing projects in physics teaching, and they all wanted to be adopted nationally.

The quotation from Hulsizer at the beginning of this chapter was from a special issue of *Physics Today* dealing with "introductory physics education." Among the wide range of perspectives presented,[42] a revolt against the PSSC national discourse was clear in some of the contributions. Some authors considered that what society required from American schools was "educating philosopher-scientists" instead of an army of professional scientists and engineers.[43] Others were against the PSSC pretensions of national sovereignty, calling for course diversity as a desired reflection of the pedagogical and national virtues of American culture.[44] Among these, Harvard's Project Physics would become one of the PSSC's main competitors at both a national and an international level. In the early 1960s, while the PSSC was implementing its strategy of national expansion, Jerrold Zacharias chaired a panel on education, as part of the President's Science Advisory Committee. In addition to eulogizing the PSSC program, he revealed some of his views on national schooling: "The school 'system' is a natural unit for reform. The system is an organic, semi-autonomous unit of education, with pension plans and supervisors, principals, promotion and hiring procedures, specification of jobs, adoption committees. It has electoral responsibilities, public relations problems, budgetary experience. World War II measured armies by divisions because the division was the smallest military unit that included all services—infantry, artillery, tanks, and air. The school system is the 'division' of education."[45] These analogies were not rare in the 1960s.[46] They were grounded in a cultural context shaped by wartime experiences, which had brought the nation together as an integrated system to fight foreign enemies. After World War II these alignments survived in the minds of many people who had played a major role in the war effort, such as some of the PSSC leaders.

Victory in World War II and the start of a space race reinforced a nationalistic perspective in the United States that enhanced political, economic, and institutional support for endeavors such as the PSSC and contributed to shape the ethos of many of the PSSC team members.[47] Thus, in his President's Science Advisory Committee report, Zacharias felt entitled to omit two major aspects. First, he ignored any educational research produced before the 1960s. Second, he dismissed any contemporary study produced in Europe, arguing that they would be useful only if they could demonstrate their relevance to the American context, thus stressing US autonomy.[48] The declining influence of Europe was being replaced by the emerging rivalry with the Soviet Union that configured the Cold War and its historical narratives. The launch of *Sputnik* by the Soviet Union did not start projects such as the PSSC, but it did benefit them, at least in providing further impulse and support to the resolution of accumulated concerns about science education.

CIA and NSF reports on the efficiency of the Soviet Union's centralized system of high school education and university training made the comparative assessment of the failures of American science education even more dramatic. According to these reports, unlike the Soviet Union, the United States, with the political autonomy of its state governments and the stratification of its school system, could hardly aspire to produce a significant number of scientists in a short period of time, as required by national interest. Zacharias would surely have agreed with that. Opposition between American democracy and Soviet totalitarism was a frequent argument in NSF reports regretting sourly the US lag revealed by the *Sputnik* affair. However, other US experts considered that while Soviet education was shaped by ideological indoctrination, this had little effect on the training of students in subjects such as mathematics, physics, and chemistry. Scientific laws and technological problems were in fact the same whether presented in a communist or in a capitalist guise.[49] These reports obviously simplified the key features of American versus Soviet (or Russian) science education by reducing them to democracy versus authoritarism: both countries had national cultures of science, education, and politics that were more diverse and complex than captured by these two adjectives. What matters for our purposes here is that this line of reasoning represents another way of making the nation (by reference to an external enemy). In this framework (international) comparison was relevant but was instrumentalized to serve a predominantly ideological, rather than educational, agenda.

Cold War historiography has greatly emphasized US-Soviet confrontation, in a narrative loaded with exceptionalism and a basic bipolarity.[50] If we look beyond the timeline imposed by the post-1945 emergence of superpower rivalry, however, we encounter longer-term narratives that can give a richer account of the historical phenomena relevant to understanding science education during the Cold War.[51] Comparative studies made with a view to learning more, rather than to establish superiority, appear to be a fundamental tool in the development of all national networks of education since the nineteenth century. Observers circulated officially or secretly across nations to compare the unknown with the known and to draw conclusions able to improve teaching and research back home. The United States was no exception.[52] Comparison involves a type of observation that is never symmetric (an observer is always subjective and politically biased) but it can at least be productive of new insights rather than simply used to dismiss the other. In this context, there was an international context for science education that was rapidly expanding, in which the United States would come to play a major role, but nonetheless, in which there could be reciprocal learnings, as the imperfect geometry of the "international" suggests.

The International PSSC

In 1959, alongside a map of the PSSC's distribution in America, ESI's report included a picture of Prime Minister Nehru examining PSSC materials accompanied by US officers at an exhibition organized in India.[53] Two years earlier a translation into Thai of the PSSC textbook's first volume had been made by a recent Harvard physics PhD who would subsequently occupy important government positions in Thailand.[54]

The goal of the PSSC had been to develop American curriculum reform. During the late 1950s, however, in the course of developing the PSSC materials, the project started to receive expressions of interest from foreign individuals and governments. ESI responded to these demands. As they grew in number the Committee was obliged to develop a plan for its international projection. It conceived of the international zone as divided into three types of countries: (1) "Advanced Nations—where there is something for both sides to learn": Sweden, Norway, Denmark, New Zealand, Yugoslavia, Spain, Israel; (2) "Intermediate Nations—The problem is primarily one of adapting the PSSC course": Japan, India, Latin America, or "Countries with relatively well established systems of education"; (3) "Emerging Nations—Where considerable aid work has to be done before PSSC can be of benefit: African Nations" or "Underdeveloped countries." Projects of the first type could be funded with the help of the NSF. Those of the second and third types would require funding from other agencies.

Just before the publication of the PSSC course materials, ESI reported having received requests for information from 350 individuals in foreign countries (plus 200 from Canada). That year, ten foreign visitors participated in PSSC summer institutes and publicized the project in Denmark, Germany, Finland, and England. In 1960 the number of visitors was expected to multiply by six. Three Spanish-speaking countries, Japan, and Sweden requested permission for the production of literal translations of the PSSC textbook into their national languages. Other countries, such as England, Canada, Germany, and Brazil, asked permission to adapt the course. The US Information Agency wanted to have PSSC materials (including films) for distribution in their network.[55]

By 1966 more than fifty foreign teachers had attended PSSC teacher-training programs in the United States.[56] This mode of operation produced results. Thus, for instance, a summer institute visit by a Swedish representative had a major role in the development of a trial program in Sweden aiming to adapt the PSSC materials. Moreover, Norwegian teachers joined the project to form a Scandinavian team cooperating to produce new teaching materials.[57] A similar experience occurred in New Zealand.

ESI contended that some of the pilot countries could adapt the materials to their educational needs by including additional topics,[58] and that "direct translation . . . will rarely be the optimal solution."[59] Some of the foreign editions adopted this view: the Norwegian edition incorporated an additional chapter, extracted from the PSSC Advanced Topics program,[60] and the Spanish edition was published in two volumes in order to be used in a two-year course (instead of the original one-year PSSC course). By 1964, only the Italian translation included all the course materials.[61]

After 1960 the bulk of the PSSC internationalization program was devised through the development of courses abroad.[62] Between 1960 and 1964 there were summer institutes in Israel, England, New Zealand (three), Brazil (two), Sweden, Italy (three), Nigeria, Uruguay, Costa Rica, and Chile, and conferences on the PSSC (or partially dealing with it) in India, Austria, France, Israel, Italy, Japan, and Southern Rhodesia.[63]

Foreign editions of the PSSC text were published in Denmark, Italy, Israel, Japan, Brazil, India, Sweden, Colombia, Canada, Spain, Norway, Turkey, (French) Canada, and France. Some of the films were in the course of being translated into Italian, they were purchased in India, and one of the films was translated into Spanish and shown at the 1963 Interamerican Conference on Physics Education (Rio de Janeiro) and at major universities in Mexico, Uruguay, Costa Rica, and Puerto Rico.[64]

In 1960 the PSSC began to develop a relevant on-site involvement in Europe at the request of the Organization for European Economic Cooperation (OEEC) and the NSF.[65] That year, the OEEC had organized at its headquarters in Paris a conference on physics education with the support of the International Union of Pure and Applied Physics. A report and a plan to develop pilot projects on science education in Europe were produced. Established in 1948 as a permanent institution to manage the Marshall Plan aid, the OEEC was now convinced that an economic recovery plan should involve the reform of school science education in its European member states.[66]

The PSSC team was approached by OEEC officials, and after a visit to England by Friedman, plans started to take shape for the organization of a PSSC summer institute in Cambridge (United Kingdom). It was held in August 1961 with the participation of teachers from France, Spain, Portugal, Ireland, Italy, Austria, Germany, Turkey, Greece, Iceland, the Netherlands, Switzerland, Norway, Denmark, the United Kingdom, Yugoslavia, Belgium, and Sweden.

The aim of the PSSC delegation, led by Uri Haber-Schaim, was to have truly intensive sessions, allowing participants to leave the institute with a range of written documents leading to the development of pilot projects in the different countries. These meetings were also conceived as places where the rights for translation of the PSSC materials would be negotiated. The Cambridge meeting indeed produced some of these drafts, developed not from a national perspective but through multinational teacher teams (except for a report on Yugoslavia).[67] Subsequently, Haber-Schaim considered that an international organization like OEEC would not have the capacity to develop such a project. It was preferable to leave the initiative to national groups as exemplified by the model experience of the (American) PSSC.[68]

The circulation of PSSC staff members across the world also played a major role in the internationalization of its products. Friedman and Haber-Schaim were arguably the members of the project who had a greater input in the development of the project abroad. Haber-Schaim led summer institutes in Europe, Latin America, Africa, and Japan. He would subsequently lead the preparation of the second and third editions of the PSSC course in the United States. Friedman traveled to the United Kingdom, India, and Pakistan and prepared the implementation of the PSSC there.

In addition, the project benefited from the international impact of US physics research and the worldwide circulation of the physicists connected to it. Thus, Philip Morrison, a member of the PSSC since its inception and a physics professor at Cornell, was in Europe, Israel, India, and Japan in 1960 for research purposes. During his trip he distributed PSSC materials and publicized the project.[69] MIT physicists not directly connected to the PSSC program did the same.[70] During his trip to India, Morrison expressed his surprise about Friedman having arrived in that country earlier than him and thus overtaking him in introducing the PSSC there—he used a metaphor which illustrated precisely the political and commercial substance of the PSSC international mission: "Had Columbus met the Admiral of Cadiz in Havana harbor he would have a little greater surprise."[71]

The earliest foreign editions of the PSSC course were translations into Spanish and Portuguese. In Latin America, there were three PSSC translations used in physics teaching a few years after the release of the PSSC materials in the United States. The first translation of the PSSC textbook was produced in 1962 in Spain and marketed in Spain and Latin America by the publisher Reverté.[72] It was used, for instance, in

Mexico, where knowledge of the PSSC was surely introduced early on by Luis Estrada, a Mexican PhD student who was a visiting student at MIT between 1958 and 1960.[73] During the 1960s Mexican physicists such as Estrada and Francisco Medina Nicolau conducted workshops on the PSSC at the Universidad Nacional Autónoma de México, and after the reform of its physics degree in 1966, a new general physics course was introduced which included PSSC course experiments and the replication of some of its instrument kits.[74]

The second translation of the PSSC course into Spanish was published in 1964 in Colombia by a team of ten Colombian MIT alumni and a group of physics and engineering professors from the major universities in Bogotá, with the support of the Organization of American States (OAS), MIT-Club Colombia, and the Colombian Association of Universities.[75] It was led by Alberto Ospina, a military naval engineer trained in electronics at MIT, who had witnessed the early development of the PSSC before returning home in 1958.

A few years earlier, the PSSC had been published (between 1962 and 1964) in Portuguese in Brazil. It was the result of a long-standing effort among Brazilian scientists and educators to improve science education, which was helped by the support of UNESCO in the creation of the Instituto Brasileiro de Educação, Ciência e Cultura (IBECC),[76] the development of ambitious plans to produce and distribute science kits in schools, and the support of US funding (Rockefeller Foundation, Ford Foundation) and inter-American organizations based in Washington, DC (OAS). The IBECC had a major role in the development of science education programs in Brazil and across Latin America during the 1960s and 1970s.

The IBECC was created in 1946 in Rio de Janeiro to administer UNESCO's projects in Brazil. Its involvement in science education came through the subsequent establishment of a São Paulo branch and the initiatives, from the early 1950s, of Isaias Raw, a young medical researcher based at the Universidade de São Paulo. Raw's interest in science teaching had taken shape since the late 1940s through his work as a science teacher in a São Paulo private school (conducted simultaneously with his university medical studies), where he edited a journal devoted to the teaching of science.

After getting his medical degree and a research stay in Severo Ochoa's biochemistry laboratory in New York, Raw returned to São Paulo with the idea of starting a project to change the standard paradigm of the teaching of science in Brazil. As the scientific director of IBECC's São Paulo branch, he conducted a large series of initiatives on science education and popularization, including exhibitions, clubs, fairs, talent competitions, and TV programs. Furthermore, he developed a major program for the design and production of school science equipment and experimental kits. Started as an in-house project, it soon received funding from the Conselho Nacional de Pesquisas and from several Brazilian state governments. As the project grew to industrial size, it was a major success for Raw to secure funding from the Rockefeller Foundation (1957), which already played a significant role in the funding of the new campus of the Universidade de São Paulo and especially its medical faculty.

In 1956 Raw visited the United States and became acquainted with incipient American educational projects such as the PSSC. Subsequently, Friedman was designated by the Ford Foundation to visit São Paulo, but he soon became ill and was unable to travel. However, through Raw's contacts at the Rockefeller Foundation and subsequent missions of US scientists to Brazil, it became clear that the country had an enormous potential for the development and marketing of science pedagogical packages. Thus, in 1961 a funding agreement was established with the Ford Foundation for the distribution of IBECC's experimental kits in Brazilian schools, the training of science teachers, and, last but not least, the distribution of US pedagogical materials in Brazil.[77]

The IBECC followed the progress of the PSSC project by using some of the preliminary copies of the course material and working on them between 1959 and 1960. In 1961 it published the translation of the laboratory guide and started to produce some of the PSSC equipment. A member of the IBECC attended the 1961 PSSC summer institute in Massachusetts.

A PSSC institute was held in São Paulo in January 1962, with funding from the OAS and the Ford Foundation and technical advice from the NSF. The institute staff was composed not only of Americans but also included lecturers from Chile (Darío Moreno), Costa Rica, and the IBECC (Rachel Gevertz). Participants were from Brazil (nineteen), Colombia (five), Chile (four), Paraguay (four), Argentina (three), Uruguay (three), Costa Rica (one), Nicaragua (one), Panama (one), and Peru (one). Later on that year, another PSSC summer institute was held in Brazil, this one fully developed by IBECC staff, and ran simultaneously in Costa Rica and Uruguay. By then almost all the PSSC equipment was available through local production.[78]

In this context the translation of the PSSC textbooks into Portuguese was carried forward by a team of science teachers and university physics professors at the Universidade de São Paulo, the Universidade de Minas Gerais, the Pontifícia Universidade Católica do Rio de Janeiro, and the Universidade de Brasilia, where the books were published. Between 1964 and 1971 around four hundred thousand copies of the PSSC course (split into four volumes) were sold in Brazil.[79]

Moreover, as a follow-up to its 1960 Paris conference, in 1963 the International Union of Pure and Applied Physics organized a conference on physics in general education in Rio de Janeiro with the support of UNESCO, the OAS, the Brazilian Ministry of Education and Culture, the Conselho Nacional de Pesquisas, the Centro Latinoamericano de Física, and the Centro Brasileiro de Pesquisas Físicas. The meeting gathered around 150 participants from across Latin America, Europe, the United States, and some Asian countries.[80]

This movement of teachers and physicists across countries was promoted and supported by national and international institutions. The NSF stated that its priority in relation to the science curriculum was the "development of materials potentially useful to schools across the country." However, its mission was also to cooperate with other national and private agencies specializing in foreign affairs to help circulate pedagogical materials, scientists and science teachers, and educational information, in order to fulfill "United States foreign policy goals."[81]

NSF officials confessed to being proud of the interest shown by other countries for new US curriculum materials. They were conscious of the regional importance of Latin America for the international expansion of their national projects, seeing themselves as having "special responsibilities in working with Latin American countries and the state universities in Central America." Moreover, they suggested that with regard to the sending of publications and materials, "information should be given as freely to people in other countries as to people in the United States," but since foreign relations were a complex matter,[82] discretion and cautiousness should prevail in order not to give the impression of "pushing United States materials in other countries," while helping those making requests.[83] Notwithstanding their prudence, the international circulation of PSSC materials was massive. For instance, in 1961 a copy of the PSSC Science Study Series book *Crystals and Crystal Growing* (1960) was mailed to libraries in practically every country in the world (with several copies sent to most Latin American countries).[84]

The international exposure of the PSSC project did not appear to change substantially the basic outline of the operations of ESI and the Science Teaching Center at MIT. However, in a few cases, they benefited from direct collaboration with foreign practitioners linked to countries that were developing vigorous projects of science education reform connected to the American PSSC program. Thus, in the development of its Advanced Topics program, between 1960 and 1963, ESI made use mainly of American staff and consultants. However, it also engaged some teachers from other countries, such as Sweden, Canada, Brazil, and New Zealand, who were able to attend US summer institutes and to work in Massachusetts for some time, with the help of funding from their governments or UNESCO. By 1963 the course had been used on an experimental basis in Sweden, Norway, Italy, Israel, Brazil, Uruguay, Chile, Canada, and New Zealand, and members of the Brazil team, such as Gevertz and Raw, spent long periods in Cambridge, Massachusetts. The ability of foreign physicists and teachers was valued by PSSC staff, but not always so. On some occasions foreign requests for collaboration were rejected or considered insufficiently relevant to commit to, even if they came from centers with a good record with the PSSC program such as the Universidad Nacional Autónoma de México.[85]

A different and more multilateral approach characterized the projects developed by UNESCO in Latin America. UNESCO (United Nations Educational, Scientific and Cultural Organization), established immediately after World War II, played a major role in the international development of science education programs worldwide. UNESCO's science education initiatives during the 1960s and 1970s divided the globe by coupling world regions with scientific disciplines: a program in physics teaching for Latin America, in biology for Africa, in mathematics for the Middle East, and in chemistry for Asia.[86]

UNESCO's member states represented a wide range of political approaches, from pacifist internationalism to Cold War engagement, and different priorities and ideas about how to articulate international cooperation through science, education, and culture.[87] The first decades of the organization were characterized by a growing tension between an idealized global humanism, prone to nonalignment and confident in the apolitical and universalist nature of culture, education, and science, and a pragmatic and instrumental politics, represented mainly by the United States, which sought to fight the Cold War also on the cultural and educational front and to collapse international diversity into its own national interests and outlooks.[88]

UNESCO's Division of Science Teaching was created in 1961, and its organization can be understood partly as a key element in American foreign policy aimed at placing as many US representatives as possible in relevant positions in international organizations. Its first director was Albert Baez, an American physicist trained at Stanford who had been part of the PSSC film production unit. His hiring at UNESCO was undoubtedly advantageous for the United States and for the internationalization of one version—strongly supported by the US government—of American culture expressed through science pedagogy (PSSC). It also had major consequences for the development of physics-teaching projects in Latin America.

In starting his new job in Paris, Baez prepared a pilot project for the implementation of new approaches in the teaching of science. His model was obviously the PSSC.[89] He resolved to implement such a project in Latin America, because he spoke Spanish. After presenting his project to UNESCO authorities and getting their approval, Baez constituted a team with Nahum Joel from Chile, Robert Maybury from the United States, and Alfred Wroblewski from Poland and divided the program into three sections—physics, chemistry, and biology—keeping the direction of the physics program for himself.[90]

Joel, with the help of a team including his assistant Darío Moreno, had previously developed PSSC institutes in Chile, and he had a key role in the development of UNESCO projects in Latin America. Maybury had previously met Baez at the University of Redlands in the United States, and many years later he recalled that when asked to join the UNESCO project: "Al's vision resonated with me, for as with many other professionals of that era, I was influenced by John F. Kennedy's statement: 'Ask not what your country can do for you, but ask what you can do for your country.'"[91]

At a UNESCO conference at the Paris headquarters, Baez met a member of IBECC's team, who persuaded him that his project should be developed in Brazil. Baez was invited to visit IBECC's premises in São Paulo and was convinced that Raw's initiatives had developed an advanced and extremely adequate setting for the implementation of UNESCO's project in Latin America, and that producing materials in Portuguese would not be a major obstacle to subsequently translating the materials into Spanish for the rest of Latin America. Thus, São Paulo became the headquarters for the development of the project in Latin America.[92]

UNESCO's Brazilian pilot project could rely on the network of Latin American science educationists previously developed by the IBECC and by the Chilean group led by Nahum Joel and Darío Moreno. It gathered twenty-five professors and teachers from eight Latin American countries, and in the course of a year (1963–1964) it produced five books, seven kits of inexpensive laboratory materials, eleven short films, one long film, and eight television programs. At the end of the year, another thirty-five university science teachers from seven more Latin American countries (thus, fifteen in total) attended a seminar to test and evaluate the materials. Some of them, including those from Argentina, Chile, and Venezuela, formed teams to extend the pilot project activities to their countries.[93] Baez worked as director of the Division of Science Teaching until 1967. The success of the Latin American pilot project allowed the division to develop similar projects in Africa, Asia, and the Middle East.[94]

The Transnational PSSC

The development of the national and international PSSC was subjected to different experiences that involved movement across borders and thus interaction with different national traditions all over the world, which nonetheless did not always result in the establishment of a dialogue between different cultures of science education.

For instance, the presence of foreign students at MIT and other US universities assuredly promoted the internationalization of the PSSC program through translation and use abroad. As we saw in the previous section, this was the case with students from Colombia, Mexico, Thailand, and to some extent Brazil and Chile. The agency of these students was characterized, first, by their participation in the international scene and, second, by the skills they were obliged to develop in order to understand other national cultures. They were surely transformed by their experience abroad to a greater or lesser degree. The significance of their presence is relevant to understanding not only the internationalization of PSSC and US physics at large but also the educational and research development of these US institutions. However, this issue has hitherto been rarely analyzed.[95]

PSSC's internationalization also prompted the incorporation of some physicists and foreign science teachers (Swedish and Brazilian) into some of MIT's projects, although this situation was unusual. It offered them a privileged access to MIT's scientific, educational, and cultural resources. Their experience also involved personal and cultural transformations, comparison, tensions, and partial hybridization of different national cultures.

In turn, the intensive and extensive travels of the leading PSSC staff and their exposure to different national cultures might have affected their perspectives of science and education. One would want to investigate whether this international exposure had a relevant impact on subsequent editions of the PSSC's pedagogical package. For instance, did the knowledge acquired by the PSSC leaders during their world trips to promote the project result in the subsequent adaptation of the PSSC materials to an international audience? This is difficult to say, especially because after the second edition of the course was published (1965), most of the original team disbanded because of the early deaths of some of its leaders (e.g., Friedman and Finlay), their return to physics research, or their involvement in policy (Zacharias).

Traveling abroad arguably involves personal transformation to some extent and is commonly a good antidote against nationalism; however, it does not necessarily dissolve the driving force of nationality. On the contrary, the 1960s map of the world presented a nation-state system that maintained nationality as a fundamental quality of traveling, whether as a right-of-way or as a veto-of-access (with different grades in between determined by national and international migration policies).

In this context, the international circulation of PSSC team leaders was particularly shaped by a mission that was not only educational, scientific, and commercial but also fundamentally national in nature and that linked the institutional and the personal. As in a traditional classroom, the position of the student who comes to learn and that of the teacher who comes to teach are obviously not the same, so to a large extent the PSSC staff traveled abroad to teach and to fulfill US foreign policy goals in a traditional fashion. When Morrison portrayed himself as Columbus and Friedman as "the Admiral of Cadiz," in the letter written during their 1960 world tour to publicize the PSSC, he provided an account of the PSSC international endeavor couched in a language of military and commercial conquest.[96] The implications of his metaphor are particularly powerful and inescapable, taking into account the importance of Latin America for the international PSSC and the fact that Morrison wrote these words while visiting (postcolonial) India. Anyway, without overinterpreting this metaphor, Morrison's and Friedman's correspondence during their trips to Europe, India, Pakistan, and Japan makes clear that the focus and rationale of their mission was to enlighten foreign physicists and educators through PSSC exposition and the conferring of material gifts. Although their letters also mention some sightseeing and show some interest in the cultural heritage (museums, monuments) of these countries, they say nothing about what, if anything, they learned from foreign professional counterparts with regard to other national cultures of physics teaching. In this context the world circulation of PSSC team leaders exemplifies how the international can often be driven by a purpose that is national in fundamental ways.

It is fair to say that basically the new projects developed at ESI and MIT's Science Teaching Center remained American to their core in terms of their staff and their outlook even though some of them had international ambitions. On the other hand, the extensive internationalization of the PSSC was possible thanks to a network of national, private, and international organizations, whose interests converged on this pedagogical package originally conceived at MIT. All the same, organizations are staffed and directed by humans, whose engagement in the making and practice of knowledge is a major force that does not always align completely with organizations' official statements.[97] The Division of Science Teaching, directed by Baez, defined UNESCO as a "catalyzer" and "internationalizer" but emphasized the role that individual countries, individual teachers, and specific teams of people had had in the shaping of new science-teaching materials and outlooks.[98] Opening the door to a more symmetrical interaction with other national collectives allowed in this case further effacement of national boundaries, contributing to the articulation of an international framework amenable to a potential situation of transnationalism.

In this context, there were major agents in the internationalization of the PSSC who had attributes that we can call *transnational* and that made them particularly well suited to conduct this task, while pursuing their personal agendas. Isaias Raw and Darío Moreno, for instance, were this type of actor. Here, I am going to focus on Uri Haber-Schaim and Albert Baez.

Haber-Schaim had a leading role in the practical implementation of the international PSSC; he led the production of the third edition of the

PSSC materials and was director of the PSSC project between 1961 and 1974. He was born in Berlin (Germany) in 1926, moved as a child to Palestine in 1933, and graduated from the Hebrew University in 1949, right after the creation of the State of Israel. He was part of Israel's Science Corps (HEMED), an organization of scientists connected to the army, and had a major role in the development of a defense industry in the context of growing hostilities with the surrounding nations, which made this a central project in the making of Israel. Accordingly, Haber-Schaim was sent to the University of Chicago to study nuclear physics (PhD, 1951), and he returned to the Weizmann Institute and the Israel Atomic Energy Commission (HEMED's research bases).

After repeated professional arguments with the director of the Israel Atomic Energy Commission, which led to his resignation, Haber-Schaim moved to a position in German-speaking Switzerland and shortly afterward immigrated to the United States. Haber-Schaim's clash with the Israel Atomic Energy Commission can be seen partly as the tension between a profession used to freedom (scientist) and a management based on military discipline in a war situation. This tension also suggests a clash between different political visions on how to build the Israeli nation-state. In the United States, Haber-Schaim worked at the University of Illinois (1955–1956) and as assistant professor at MIT (1957–1960). Beginning in the late 1950s he devoted himself fully to the development of the PSSC and from then on built a professional career in the field of science education, making the Boston area his home base.[99]

Albert Baez, the first director of UNESCO's Division of Science Teaching, was born in Puebla (Mexico) in 1912 but immigrated to New York with his family at the age of two. He returned for a year to Mexico when he was seven, an experience that he claimed, later in his life, had a major role in maintaining his ties with his country of birth and in preserving his ability to speak Spanish.[100] However, Baez's formal education was American. In 1933 he obtained a BA in physics and mathematics from Drew University, two years later an MA in physics from Syracuse University, and in 1950 a PhD in physics from Stanford, where he developed a research career in X-ray optics. In 1951 he obtained a UNESCO appointment in Iraq. Subsequently, he worked at the University of Redlands and again at Stanford. In 1957 he was called by Jerrold Zacharias to join the PSSC project at MIT, where he worked mainly on film production. His work for the PSSC project would shape the rest of his professional career.[101]

In his memoirs about his career at UNESCO, Baez recalled that before teaching at Redlands he worked for some time in the Cornell Aeronautical Laboratory's Operations Research Group. According to him this was an intellectually challenging job, but he became increasingly worried about being involved in scientific and technological collaboration in the war effort. He read an article in the *New York Times* about UNESCO's mission that led him to inquire about any job openings, hoping to devote his professional life to peaceful uses of science for the benefit of mankind. Later on, he was invited to collaborate in a UNESCO project to set up science laboratories at the University of Baghdad. This first mission, as well as his work for the PSSC, surely helped in his being recruited subsequently as the head of the Division of Science Teaching.

Baez's expression of humanistic ideas in his memoirs was surely genuine, although they are a later reconstruction. Baez's and Haber-Schaim's careers show a move from military-driven science to science education and in parallel from nation building to international articulation. Both had very successful careers in science education, and they found there a way to distance themselves from scientific research for military purposes. Although this might have been the goal of many of the PSSC physicists who had participated in the wartime effort,[102] the actions, careers, and language of Baez and Haber-Schaim contrast with those of Jerrold Zacharias, for instance.

However, the main argument here is that it was not by chance that individuals like Baez and Haber-Schaim were two of the major leaders in the internationalization of the PSSC. Their upbringing and life experience across several national cultures prepared them to understand and to develop the types of actions involved in internationalization, to an extent that other PSSC staff members (regardless of their competence in physics and education) were not as ready to fulfill. Beyond their language skills, their life and professional experiences were transnational, as they combined different national and cultural identities throughout their lives and used these attributes to build bridges and establish dialogues.

Baez claimed he felt linked to Mexico. In his memoirs he also confessed that in starting the UNESCO projects he originally had a rather arrogant perspective as to the superiority of American science education projects and their makers. During the development of these projects in Latin America, however, he became progressively more humble in recognizing the cleverness and capacities of Brazilian colleagues.

Haber-Schaim had an even more complex itinerary in national perspective. He, like Baez, was born in one country but grew up in another one. Moreover, he worked in the context of an emerging nation-state, a process to which he contributed through his scientific research. In the new State of Israel he worked hand in hand with scientists who shared his Israeli citizenship but were born in different nation-states. He subsequently lived in two additional countries and developed a career in the United States that was characterized by internationalism in science education research.

As transnational actors both Baez and Haber-Schaim were able to travel to foreign countries and to learn from foreign colleagues with an open mind, or at least with a mind less circumscribed by nationalist preconceptions that were rampant at the height of Cold War rivalry and the making of American hegemony—the projects that had inspired the PSSC in the first place. Their capability in this context was characterized by a relevant fluidity with regard to nationality, which allowed them to manage national allegiances with more degrees of freedom than other types of historical actors. Their UNESCO and PSSC work, respectively, shows an engagement with the communities of scientists and educators in the countries they visited. They recognized the value of "the other" for the purpose of improving science education with reference to the requirements and characteristics of each national context. In contrast, there were other historical actors holding perceptions and performing roles with a strong involvement in internationalization but having a major national bond as well, exemplified in this chapter by Zacharias, Friedman, and Morrison. The development of Baez's and Haber-Schaim's transnational agency was shaped by both the nature of their multinational upbringing and the nurture of their international experiences, shaped by their capacity to engage and communicate with different national traditions of science and education.

A question that remains is to what extent the different translations of the PSSC materials were faithful to their American originals. Were they transformed by the different national outlooks and experiences in science and education in which they were adapted? The PSSC translations were undoubtedly the product of internationalization and to some extent of transnationalism (of some of its promoters). But can the PSSC translations be seen as transnational products?

Many of the translations of the PSSC textbook were mostly literal. This was the case, for instance, for the two Spanish translations. However, the Scandinavian team that adapted the PSSC materials added new chapters to the book, and some of the translations (e.g., the one produced in Spain) divided the book into two volumes to adapt it to a two-year course.[103] In other places such as Brazil "participants utilized the text produced by the PSSC and other modern texts as a base for their own studies, but they developed and produced a set of modern learning aids, which they themselves had adapted to the local economic education needs." The Brazilian project team at IBECC thus transformed the PSSC American course mainly through a focus on methodology aimed at adapting it to local needs, but they equally focused strongly on content development. They could do so because they had an excellent starting point based on a selection of renovated curriculum contents made by the American PSSC team.[104]

With the increasing international availability of new curriculum projects in the 1960s and 1970s and the development of international teams and cross-national experiences such as UNESCO's pilot physics project at IBECC, it would be accurate to say that some of these pedagogical products not only crossed national cultures of science and education but also contributed to dissolving them. In other words, their cross-national circulation not only contributed to strengthening the action of US national science and education in a wide range of other national contexts, through direct exchanges or interactions in the field of international organizations. More important, it was arguably able to weaken the original national characteristics of these products and in addition could lead to their endowment with a somewhat lasting transnational condition. Further research based on a closer comparative analysis of several PSSC translations is still required to fully support this transnational claim.

Final Remarks

The structure of this chapter might give the impression that during the 1960s the efforts toward science curriculum reform progressively moved from the local to the national, from the national to the international, and from there to transnational science education. This has been a suitable order of presentation, chosen for conventional narrative reasons that advise following a chronological order, moving from particular to general, or going from simple to compound. However, this would be a simple linear interpretation that would hide the complexity of the world of science and education. The PSSC had local, national, international, regional, and transnational elements. All of them are relevant if we want to achieve an accurate historical understanding of this research object, and their relationships are not linear and hierarchical.

Furthermore, the coexistence of all these scales in a historical object such as the PSSC cannot be taken for granted. It is as important to know that it had each of these qualities as to understand why it had them and why we as historians confer them on the PSSC. As I showed in the first section of this chapter, nationality is a complex concept. The PSSC was American not only because almost all of its members were born in the United States or because it was developed at MIT and some other American universities and schools, but especially because it was part of a vigorous project of nation building within US territory and abroad. Nation building was performed through intranational science education reform developing and strengthening networks and communities within a country, by making comparisons with other nation-states or geopolitical regions, and by implementing large-scale programs of internationalization. Unpacking these categories is crucial to really understanding and using them appropriately and accurately.

Among the main categories discussed in this chapter, the transnational is the most elusive, since, as we saw, many international phenomena can be more akin to the national than to the transnational. However, this historical claim could be nuanced by future historiography subject to updated worldviews and cultural concerns displaying the utmost relevance of the transnational, whether in a world of nation-states or beyond it. Moreover, the distinction of the transnational from the international should play a major role in enriching the historical field with more subtle accounts integrating a wider range of objects and actors from a larger number of national cases and providing a better understanding of the phenomena that lie in the interstices of nation-states or do not succumb to the logic of the national. The examination of the production of the local, national, regional, international, and transnational PSSC presented in this chapter represents an attempt to integrate all these views and to demonstrate the importance of discussing the transnational as a vector for historiographical improvement.

The unraveling of the transitions and connections between our different scales of analysis is not a simple matter. It will require major effort by historians of science, technology, and medicine to update their tradition by overcoming the nation, which is still the most obvious site of their professional and intellectual employment.

Notes

1. R. I. Hulsizer, "The New MIT Course," *Physics Today* 20, no. 3 (1967): 55–57.

2. Anthony P. French was a British physicist seasoned at Cambridge and Los Alamos in the US-British atomic bomb project, who had returned to the United States in 1955 and had transformed his university courses at the University of South Carolina into *Principles of Modern Physics* (New York: Wiley, 1958).

3. A. P. French, "A New Introductory Course at the Massachusetts Institute of Technology," 1963, PSSC Records, MC626, box 9, folder "New Courses," Institute Archives and Special Collections, Massachusetts Institute of Technology, Cambridge, MA (hereafter MIT Archives).

4. See, e.g., U. Haber-Schaim, "Precollege: The PSSC Course," *Physics Today* 20, no. 3 (1967): 25–31.

5. Richard Gunstone, ed., *Encyclopaedia of Science Education* (Berlin: Springer, 2015).

6. S. W. Leslie and R. Kargon, "Exporting MIT: Science, Technology and Nation Building in India and MIT," *Osiris* 21 (2006): 110–130.

7. Ernest Gellner, *Nations and Nationalism* (Oxford: Basil Blackwell, 1983); Eric Hobsbawm and Terence Ranger, eds., *The Invention of Tradition* (Cambridge: Cambridge University Press, 1983).

8. A. J. Angulo, "The Polytechnic Comes to America: How French Approaches to Science Instruction Influenced Mid-Nineteenth Century American Higher Education," *History of Science* 50, no. 3 (2012): 315–38; Daniel J. Kevles, *The Physicists: The History of a Scientific Community in America* (New York: Alfred A. Knopf, 1978).

9. See, e.g., Barbara B. Clowse, *Brainpower for the Cold War: The* Sputnik *Crisis and National Defense Education Act of 1958* (Westport, CT: Greeenwood Press, 1981); John Rudolph, *Scientists in the Classroom: The Cold War Reconstruction of American Science Education* (New York: Routledge, 2002); Wayne J. Urban, *More than Science and* Sputnik*: The National Defense Education Act of 1958* (Tuscaloosa: University of Alabama Press, 2010).

10. An example of this trend can be seen in the introduction to the most recent *Companion to the History of American Science*, whose editors transform the historical observation of contemporary US world hegemony into a historiographical project per se whose goal is to demonstrate "the rapid emergence of the United States as the global leader in science and technology in the twentieth century." Georgina M. Montgomery and Mark A. Largent, "Introduction: The History of American Science," in *A Companion to the History of American Science*, ed. Georgina M. Montgomery and Mark A. Largent (Oxford: Wiley, Blackwell, 2015), 1–5, at 4. In contrast, see Asif A. Siddiqi, "Competing Technologies, National(ist) Narratives, and Universal Claims: Toward a Global History of Space Exploration," *Technology and Culture* 51, no. 2 (2010): 425–443.

11. Pascale Casanova, *The World Republic of Letters* (Cambridge, MA: Harvard University Press, 2004).

12. Josep Simon, ed., "Cross-National Education and the Making of Science, Technology and Medicine," special issue, *History of Science* 50, pt. 3, no. 168 (2012): 251–374.

13. Ian Tyrrell, "American Exceptionalism in an Age of International History," *American Historical Review* 96, no. 4 (1991): 1031–1072; David Thelen, "Rethinking History and the Nation-State: Mexico and the United States as a Case Study; A Special Issue," *Journal of American History* 86, no. 2 (1999): 438–452; David Thelen, "The Nation and Beyond: Transnational Perspectives on United States History," *Journal of American History* 86, no. 3 (1999): 965–975.

14. Edwin H. Hall, "The Relations of Colleges to Secondary Schools in Respect to Physics," *Science* 30, no. 774 (1909): 577–586; Edwin H. Hall, "The Teaching of Elementary Physics," *Science* 32, no. 813 (1910): 129–146; C. R. Mann, "Physics Teaching in the Secondary Schools of America," *Science* 30, no. 779 (1909): 789–798; C. R. Mann, "Physics and Education," *Science* 32, no. 809 (1910): 1–5; Robert A. Millikan, "The Problem of Science Teaching in the Secondary Schools," *School Science and Mathematics* 9 (1925): 966–975; W. E. Brownson and J. J. Schwab, "American Science Textbooks and Their Authors, 1915 and 1955," *School Review* 71, no. 2 (1963): 150–180.

15. See Josep Simon, "Physics Textbooks and Textbook Physics in the Nineteenth and Twentieth Centuries," in *The Oxford Handbook of the History of Physics*, ed. Jed Z. Buchwald and Robert Fox (Oxford: Oxford University Press, 2013), 651–678; Josep Simon, "Textbooks," in *A Companion to the History of Science*, ed. Bernard Lightman (Oxford: Oxford University Press, 2016), 400–413.

16. See, e.g., F. Watson, P. Brandwein, and S. Rosen, eds., *Critical Years Ahead in Science Teaching: Report of Conference on Nation-wide Problems of Science Teaching in the Secondary Schools Held at Harvard University, Cambridge, Massachusetts, July 15 to August 12, 1953* (Cambridge, MA: Harvard University Printing Office, 1953); Rudolph, *Scientists in the Classroom*.

17. David Kaiser, "Turning Physicists into Quantum Mechanics," *Physics World*, May 2007, 28–33; Rudolph, *Scientists in the Classroom*; William C. Kelly, "Physics in the Public High Schools," *Physics Today* 8, no. 3 (1955): 12–14.

18. Jerrold Zacharias, "Memo to Dr. James Killian, Jr. Subject: Movie Aids

for Teaching Physics in High Schools, Massachusetts Institute of Technology, Department of Physics, March 15, 1956," Massachusetts Institute of Technology Oral History Program, Oral History Interviews on the Physical Science Study Committee, MC602, box 1, folder "Background Materials—PSSC," MIT Archives (hereafter MC602).

19. "Conference on the Production of Physicists," Greenbriar Hotel, WV, Mar.–Apr. 1955; "Conference on Physics in Education," New York, Aug. 1956; "Conference on Improving the Quality and Effectiveness of Introductory Physics Courses," Carleton College, MN, Sept. 1956; followed by meetings at the University of Connecticut and Wesleyan University and, in between, several AAPT annual conferences. Frank Verbrugge, "Conference on Introductory Physics Courses," *American Journal of Physics* 25, no. 2 (1957): 127–128; Walter C. Michels, "Commission on College Physics," *American Journal of Physics* 28, no. 7 (1960): 611; "Conference on Physics in Education," American Institute of Physics, Education and Manpower Division Records, 1951–1973, box 6, folder Conference on Physics Education, 1956, Niels Bohr Library and Archives, College Park, MD.

20. Walter C. Michels, "Committee on High School Teaching Materials (AIP-AAPT-NSTA), High School Physics Texts, Comments by Walter C. Michels for Meeting of 5/31–6/1, 1956," MC602, box 1.

21. There were a few exceptions, such as Sanborn C. Brown, who attended some of them.

22. Jerrold Zacharias, "A Proposal to the National Science Foundation, August 17, 1956," MC602, box 1.

23. Harry C. Kelly, NSF assistant director for scientific personnel and education, like Zacharias and many of the physicists involved early on in the PSSC project, had worked at MIT's Radiation Laboratory during the war. He would subsequently join the PSSC project board. Among the project's original members or supporters were MIT professors such as Martin Deutsch (who had worked at Los Alamos), Edwin H. Land (head of the Polaroid Company, located in Cambridge, MA, which had flourished during the war through military commissions), and Isaac Rabi (since 1940 associate director of MIT's Radiation Laboratory and recipient of the 1944 Nobel Prize in Physics), Nathaniel H. Frank, Francis Friedman, and Edward Purcell (Harvard). Both Rabi and Deutsch were Austrians of Jewish background who emigrated with their parents and were educated in the United States.

24. The Educational Testing Service was founded shortly after World War II by the American Council of Education, the Carnegie Foundation for the Advancement of Teaching, and the College Entrance Examination Board. To avoid political turmoil with regard to examination standardization at the state and the federal level and potential conflicts of interest, ETS was originally set up as a private nonprofit organization. G. Giordano, *How Testing Came to Dominate American Schools: The History of Educational Assessment* (New York: P. Lang, 2005), 97–98.

25. Physical Science Study Committee, "Meeting of September 8, 1956," MC602, box 1.

26. Physical Science Study Committee, "Meeting of September 14, 1956," MC602, box 1.

27. Gilbert C. Finlay, "The Physical Science Study Committee," *School Review* 70, no. 1 (1962): 63–81; Educational Services Inc. (hereafter ESI), "A Partial List of Teachers Using the PSSC Course, 1962–1963, in the United States and Canada," *ESI Quarterly Report*, Winter 1962/1963, 10.

28. The role of these actors was acknowledged by Friedman in the postface of the PSSC textbook but was hidden in many of the papers advertising the project, which placed a great emphasis on MIT, as also in recent literature such as Rudolph's *Scientists in the Classroom* and in the testimonies of the MIT physicists involved in the PSSC project, such as Zacharias, collected by the PSSC Oral History Project and preserved at MIT Archives. Friedman died in 1962.

29. J. Goodlad, *School Curriculum Reform in the United States* (New York, 1964), 64.

30. ESI, *Progress Report: A Review of the Secondary School Physics Program of the Physical Science Study Committee Initiated at the Massachusetts Institute of Technology*, Watertown, 1959, 10, ESI Records, MC79, box 6, MIT Archives.

31. Although these numbers were usually extracted from the PSSC program's own records, and therefore should be submitted to a closer and more objective quantitative scrutiny, they are no doubt indicative of a rapid and large-scale expansion of the project soon after its commercialization. S. W. Daeschner, "A Review of the Physical Science Study Committee High School Physics Course" (master's thesis, Kansas State University, 1965).

32. States such as New Jersey, New York, and Ohio had around 80 PSSC teachers; Florida and Pennsylvania, approximately 100; and Maryland, California, and Illinois, almost 150. ESI Records, MC79, box 6, folder "PSSC Area Meeting Reports, 1961–1968," MIT Archives; ESI, "A Partial List of Teachers Using the PSSC Course, 1962–1963, in the United States and Canada."

33. Project Physics was directed by F. James Rutherford (New York University), Gerald Holton (Harvard), and Fletcher G. Watson (Harvard). The textbook *Introductory Physical Science* was developed by some of the people who contributed to the second edition of the PSSC textbook, but mostly not the original team who had led the project. See, e.g., Brother John Ryan, "Report of Area Physics Teacher's Meeting, February 17, 1968, Bishop David Memorial High School, Louisville, Kentucky," and "PSSC Area Meeting Report, Loyola University, New Orleans, Louisiana, March 30, 1968," ESI Records, MC79, box 6, folder "PSSC Area Reports 1968," MIT Archives.

34. Barnard College, Bryn Mawr College, Columbia University, Cornell University, Johns Hopkins University, New York University, Rutgers College, Swarthmore College, Union College, University of Pennsylvania, Vassar College, and the Woman's College of Baltimore. M. S. Schudson, "Organizing the "Meritocracy": A History of the College Entrance Examination Board," *Harvard Educational Review* 42, no. 1 (1972): 34–69.

35. CEEB, *Bulletin of Information: College Board Admissions Tests* (New York, 1966). Extracted from L. J. Karmel, *Measurement and Evaluation in the Schools* (New York: Macmillan, 1970), 299.

36. Giordano, *How Testing Came to Dominate American Schools*; C. I. Kingson, "Science Education," *Harvard Crimson*, Nov. 27, 1957.

37. ESI, "The Matter of College Boards," ESI Records, MC79, box 6, folder "Teacher lists," MIT Archives.

38. F. L. Ferris, "Testing for Physics Achievement," *American Journal of Physics* 28, no. 3 (1960): 269–278; Catherine G. Sharp, "Minutes of the Annual Meeting of the Board of Trustees of Educational Testing Services, May 3, 1960," Educational Testing Service Archives.

39. ESI, *Progress Report*, 26–28.

40. Physical Science Study Committee, "Meeting of October 13, 1956," MC602, box 1.

41. A. Calandra, "Some Observations of the Work of the PSSC," *Harvard Educational Review* 29, no. 1 (1959): 19–22; J. A. Easley Jr., "The Physical Science Study Committee and Educational Theory," *Harvard Educational Review* 29, no. 1 (1959): 4–11.

42. Namely, Harvard Project Physics; Physical Science for Nonscientists, a course given at the University of California, Berkeley; the Nuffield Science Teaching Project; lectures given by Richard Feynman; the new MIT course, Engineering Concepts Curriculum Project; the Science Courses for Baccalaureate Education; and a critical review of available college physics courses by Mark W. Zemansky, the author of an extremely successful college physics textbook (with Francis Sears).

43. L. V. Parsegian, "Baccalaureate Science," *Physics Today* 20, no. 3 (1967): 57–60.

44. G. Holton, "Harvard Project Physics," *Physics Today* 20, no. 3 (1967): 31–34; E. E. David Jr. and J. G. Truxal, "Engineering Concepts," *Physics Today* 20, no. 3 (1967): 34–40.

45. Panel on Educational Research and Development, *Innovation and Experiment in Education* (Washington, DC, 1964), 37.

46. See, for instance, a similar analogy made by CEEB's vice president for examination and research: A. S. Kendrick, "Rainy Monday," *College Entrance Examination Board*, 1967, 2.

47. John A. Douglass, "A Certain Future: *Sputnik*, American Higher Education, and the Survival of a Nation," in *Reconsidering* Sputnik*: Forty Years since the Soviet Satellite*, ed. Roger D. Launius, John M. Logsdon, and Robert W. Smith (London: Harwood Academic, 2000), 327–362; Rudolph, *Scientists in the Classroom*; Simon, "Physics Textbooks and Textbook Physics."

48. Panel on Educational Research and Development, *Innovation and Experiment in Education*.

49. Rudolph, *Scientists in the Classroom*, 74–75.

50. These qualities are even present in Odd A. Westad, *The Global Cold War: Third World Interventions and the Making of Our Times* (Cambridge: Cambridge University Press, 2005). In contrast, see, e.g., John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe* (Cambridge, MA: MIT Press, 2006); Daniela Spenser, *The Impossible Triangle: Mexico, Soviet Russia, and the United States in the 1920s* (Durham, NC: Duke University Press, 1999).

51. An analogous long-term argument is made by Jessica Wang, "Colonial Crossings: Social Science, Social Knowledge, and American Power, 1890–1970," in *Cold War Science and the Transatlantic Circulation of Knowledge*, ed. Jeroen van Dongen (Leiden: Brill, 2015), 184–213. I thank Adriana Minor for this reference.

52. See Simon, "Cross-National Education and the Making of Science, Technology and Medicine."

53. From 1961, ESI would be involved in the creation of an institute of technology in Kanpur, India, by a consortium of eight American universities (including MIT) and funding from the US Agency for International Development and the Indian government. ESI, *1959 Progress Report*; ESI, *A Master Plan for ESI-PSSC Activities*, Watertown, 1961, 21–22 and appendix, MC79, box 6; MC602, box 2, MIT Archives.

54. ESI, *1959 Progress Report*, 17.

55. ESI, "International Interest and Problems in Connection with PSSC Physics," 1959, ESI Records, MC79, box 6, folder "Foreign Interest," MIT Archives.

56. ESI, *Physical Science Study Committee (1966): A New Physics Program for Secondary Schools*, 7, ESI Records, MC79, box 6, folder "A New Physics Program for Secondary Schools (Brochures)," MIT Archives.

57. The Swedish-Norwegian team also invited Denmark, Iceland, and Finland to join their project, but the potential expansion of the Scandinavian team met with some obstacles. The Swedish edition, though, was probably used or at least read in these countries. Letter from E. Waril to Uri Haber-Schaim, Feb. 16, 1962, Physical Science Study Records (hereafter PSSC Records), MC626, box 1, folder "PSSC International Inquiries and Reaction, 1961–1962," MIT Archives.

58. ESI, *A Master Plan for ESI-PSSC Activities*, 21–22 and appendix.

59. ESI, "International Interest and Problems in Connection with PSSC Physics."

60. This ESI program was not conceived as a course itself but as additional

chapters on more advanced topics which could be added to the teaching with PSSC materials.

61. ESI, *Quarterly Report, Summer–Fall 1964*, Watertown, 1964, MC602, box 5.

62. Letter from E. Waril to Uri Haber-Schaim, Feb. 16, 1962, PSSC Records, MC626, box 1, folder "PSSC International Inquiries and Reaction, 1961–1962," MIT Archives.

63. Before 1966 there was also a summer institute held in Colombia. ESI, *Quarterly Report, Fall–Winter 1963*, Watertown, 1963, 3–4, 24; ESI, *Quarterly Report, Summer–Fall 1964*, Watertown, 1964, MIT Archives, MC602, box 5; ESI, *Physical Science Study Committee (1966): A New Physics Program for Secondary Schools*, 7.

64. ESI, *Quarterly Report, Fall–Winter 1963*, 3–4, 24; ESI, *Quarterly Report, Winter 1962–63*, 90, Watertown, 1963.

65. ESI, "International Interest and Problems in Connection with PSSC Physics."

66. PSSC Records, MC626, box 12, folder "Correspondence 1961–1962," MIT Archives.

67. Ibid.

68. U. Haber-Schaim, "Some Guidelines on Curriculum Reform Based on the Experience of the Physical Science Study Committee," 1962, MC602, box 3.

69. ESI Records, MC79, box 6, folder "Personnel—P. Morrison Correspondence," MIT Archives.

70. An example is William Buechner, head of the MIT Physics Department, who sent PSSC materials to Korea in 1965. William Buechner Papers, 1928–1978, MC229, box 4, MIT Archives. I am grateful to Adriana Minor for this reference.

71. Letter from Philip Morrison to Edna S. Alexander, Feb. 9, 1960, 1, ESI Records, MC79, box 6, folder "Personnel—P. Morrison Correspondence," MIT Archives.

72. By the 1970s, Reverté had branches in Bogotá, Buenos Aires, Caracas, Mexico City, and Rio de Janeiro.

73. Luis Estrada, "La UNAM y yo," in *Homenaje a Luis Estrada* (Mexico City: Academia Mexicana de Ciencias, 2010), 1–6.

74. J. A. González and R. J. J. Espinosa, "Introducción al método experimental: Un nuevo curso en la Facultad de Ciencias," *Revista mexicana de física* 22 (1973): E57–E69; interview with Jorge Barojas Weber by Josep Simon, Mexico City, July 4, 2016.

75. According to the textbook's preface.

76. In English, Brazilian Institute of Education, Science, and Culture.

77. A. C. Souza de Abrantes, "Ciência, educaçao e sociedade: O caso do Instituto Brasileiro de Educaçao, Ciência e Cultura (IBECC) e da Fundaçao Brasileira de Ensino de Ciências (FUNBEC)" (PhD diss., Fiocruz, Rio de Janeiro, 2008); interview with Isaias Raw by Josep Simon, Butantan Institute, São Paulo, July 25, 2017.

78. Uri Haber-Schaim, "The Use of PSSC in Other Countries," *ESI Quarterly Report, Winter–Spring 1964*, MC602, box 5.

79. Souza de Abrantes, "Ciência, educaçao e sociedade."

80. Sander C. Brown, N. Clarke, and Jaime Tiomno, eds., *Why Teach Physics? Based on Discussions at the International Conference on Physics in General Education* (Cambridge, MA: MIT Press, 1964).

81. National Science Foundation, *Thirteenth Conference on Coordination of Curriculum Studies, Washington, D.C., May 13–14, 1965*, 2, 6–7, PSSC Records, MC626, box 10, folder "NSF Curriculum Conference 1966," MIT Archives; Finlay, "Physical Science Study Committee"; letter from E. Waril to Uri Haber-Schaim, Feb. 16, 1962, PSSC Records, MC626, box 1, folder "PSSC International Inquiries and Reaction, 1961–1962," MIT Archives.

82. We should note that the Educational Research Information Center was planned between 1959 and 1963 and established in 1964 by the US Office of Education.

83. National Science Foundation, *Thirteenth Conference on Coordination of Curriculum Studies*, 2, 6–7.

84. Address list appended to letter from Francis Friedman to Alan N. Holden, May 1, 1961, PSSC Records, MC626, box 11, folder "Correspondence 1961–1964," MIT Archives.

85. Letter from Robert I. Hulsizer to Jerrold R. Zacharias, Mar. 25, 1956, and letter from Augusto Moreno y Moreno to Jerrold R. Zacharias, Feb. 27, 1965, PSSC Records, MC626, box 11, MIT Archives.

86. This strict division applied to the original pilot projects but was progressively dissolved by the interaction and reciprocal feedback of the different disciplinary projects developed in each continent and the requirements of the local teachers. UNESCO, *UNESCO and Science Teaching* (Paris: UNESCO, 1966), UNESCO Archives.

87. Patrick Petitjean, "Defining UNESCO's Scientific Culture, 1945–1965," in *Sixty Years of Science at UNESCO, 1945–2005*, ed. Patrick Petitjean, V. Zharov, G. Glaser, J. Richardson, B. Padirac, and G. Archibald (Paris: UNESCO, 2006), 29–34.

88. S. E. Graham, "The (Real)politiks of Culture: U.S. Cultural Diplomacy in Unesco, 1946–1954," *Diplomatic History* 30, no. 2 (2006): 231–51.

89. Albert Baez Papers, Stanford University Archives, Stanford, CA.

90. As Baez was a specialist in x-ray optics and Joel was a crystallographer (with a PhD from London supervised by J. D. Bernal), it is likely that they had met or corresponded earlier for scientific research purposes. A few years later the team was expanded with a French physicist (Thérèse Grivet), a Belgian chemist (Robert Ganeff, who had previously led the science projects of the

OEEC), a Romanian biologist (Anne Hunwald), and an Indian biologist (Rachel John). UNESCO, *UNESCO and Science Teaching*, 6–7.

91. Robert H. Maybury, "From Model, to Colleague, to Friend: Honoring the Memory of Albert V. Baez (1913–2007)," accessed Feb. 7, 2017, http://auhighlights.blogspot.com/2007/03/from-model-to-colleague-to-friend.html.

92. Albert Baez, "The Early Days of Science Education at UNESCO," in Petitjean et al., *Sixty Years of Science at UNESCO*, 176–181. A longer version of Baez's account is preserved at UNESCO's archives.

93. Albert V. Baez, *Pilot Project in Physics Teaching* (Paris, 1964), 16–17, UNESCO Archives.

94. Baez, "The Early Days of Science Education at UNESCO."

95. Exceptions are Ross Bassett, *The Technological Indian* (Cambridge, MA: Harvard University Press, 2016); Zuoye Wang, "Transnational Science during the Cold War: The Case of Chinese/American Scientists," *Isis* 101, no. 2 (2010): 367–377.

96. Letter from Philip Morrison to Edna S. Alexander, Feb. 9, 1960, 1.

97. J. P. Sewell, *UNESCO and World Politics: Engaging in International Relations* (Princeton, NJ: Princeton University Press, 2015).

98. Division of Science Teaching—UNESCO, *Guidelines for a Massive World-wide Attack on the Problems of Science Teaching in the Developing Countries through the Use of New Approaches, Methods and Techniques* (Paris, 1965), 17, UNESCO Archives.

99. *Biographisches Handbuch der deutschsprachigen Emigration nach 1933*, vol. 2 (Munich: K. G. Saur, 1983), 565; A. Cohen, *Israel and the Bomb* (New York: Columbia University Press, 1998), 11, 36–37; M. Karpin, *The Bomb in the Basement: How Israel Went Nuclear and What That Means for the World* (New York: Simon and Schuster, 2006), 37.

100. After his UNESCO position, Baez ended up settling in California. There he was vindicated as a Hispanic figure by Hispanic science and engineering associations, and he also contributed to them. He was the president of Vivamos Mejor/USA, a philanthropic organization for the aid of the poor in Mexico.

101. F. Reimers, "Albert Vinicio Baez and the Promotion of Science Education in the Developing World, 1912–2007," *Prospects* 37 (2007): 369–381.

102. This is one of Rudolph's arguments (Rudolph, *Scientists in the Classroom*).

103. This might seem merely a minor change in form, but it is in fact a relevant one in terms of potential uses and teaching practices.

104. Division of Science Teaching—UNESCO, *Guidelines for a Massive World-wide Attack on the Problems of Science Teaching*, 17.

PART IV

The Nuclear Regime