
The “First Physics First” Movement, 1880-1920

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“Whether chemistry or physics should come first is thus seen to be an idle question. Physics must come first.”

Alexander Smith, noted chemistry educator, 1902¹

The issue of the grade placement of the sciences in high school is a much-discussed topic and “Physics First” strands have become regular features at physics teacher conferences. The American Association of Physics Teachers has issued a position statement and published an informational guide concerning the movement.² There is a “Physics First” website, a list-serv that provides a forum for discussion, and at least six doctoral dissertations have been completed on the topic, with more in preparation.³ The topic is not confined to the physics education community; the American Chemical Society opened a forum on “Physics First” and recently called for a conference session about the grade placement of chemistry.⁴ Biologists also recently held a symposium on “Capstone Biology” and published their proceedings.⁵

Despite all this recent attention, which science should be “first” is not a new idea but has been a feature of science education debates since the late 19th century. This article documents the “First Physics First” movement, compares and contrasts the present day arguments for placing physics first with the original arguments, and highlights the overlooked issue of how the widespread adoption and use of the “Carnegie Unit” has impacted the debate.

Early High School Physics

The state of physics education in high schools and

academies in the mid-to-late 19th century is well documented. Two “circulars,” produced by the Bureau of Education in the 1880s, detailed how physics was taught across the United States.⁶ In the first circular, Frank W. Clarke noted that while physics was taught in most high schools, there was considerable variation in its time allocation, grade placement, and teaching methods. Concerned that an important subject revealed such a diversity of practices, a second, more detailed report was commissioned. Charles K. Wead surveyed physics teachers asking them about their reasons for teaching physics, the methods used, the role of laboratory work, the time required, and the grade placement of physics. The responses noted a general tendency to offer physics in a single grade, usually the third year of high school. The most common time allocation was daily meetings for two-thirds of a year.

Shortly after these reports, in 1887, one of the first documented disagreements about the grade placement of physics appeared. James H. Shepard, in an article titled “Chemistry or Physics First; Which?”⁷ argued for a chemistry-physics order in high school, while H.L. Griffis in the next article of the same journal, “Should the Study of Physics Precede that of Chemistry?”⁸ supported a physics-chemistry order. According to Shepard, physics was a harder course for students, with “hardness” referring not to the difficulty of physics content but instead to the laboratory work that students were expected to carry out.

Shepard described how he had switched the order for a select number of students at his high school and noted that students who took chemistry before physics were more successful than those who took the subjects in the reverse order. Griffis, by comparison, based his argument on the content of the courses and presented a “physics is a foundation for chemistry” argument; that is, the study of chemistry should not be properly begun without some knowledge of the underlying physics content.

Shepard’s argument about laboratory work reflected the prevalent “mental discipline” educational philosophy of the late 19th century.⁹ In the “mental discipline” view of learning, the mind was considered a muscle that could be improved by exercise. Individual laboratory work, with its focus on precision and accuracy, provided appropriate exercise. Indeed, the importance of individual laboratory work in the acquisition of mental discipline justified the inclusion of the sciences in the traditionally classics-oriented high school curriculum, and unlike today these arguments appear in much of the early debate about the order of the science subjects.

Standardization and the National Committees

The debate about the placement of physics and chemistry came to national prominence after the Committee of Ten (CoT) met in 1892.¹⁰ The CoT was charged with rationalizing the high school program of studies and was highly influential in the history of U.S. high school education. Unfortunately, the committee is often erroneously blamed for initiating the B-C-P order of courses.¹¹

The physics, chemistry, and astronomy subcommittee of the CoT, which included Shepard as a member, reported on issues related to the physical sciences. There was immediate disagreement within the group about the grade placements of physics and chemistry. The majority favored a chemistry-physics order, arguing that the study of physics required students who were more mathematically sophisticated and more mature, though they noted, “the logical order would place physics first.”¹² The minority opinion of the subcommittee recommended a physics-chemistry order, arguing that chemistry was more abstract than physics and knowledge of physics was helpful for un-

derstanding chemistry: “the rational study of chemical phenomena is therefore of a higher order of difficulty than those of physics ... in fact it seems not unreasonable to suggest that the whole subject of elementary physics forms a desirable basis for the study of the elements of chemistry.”¹³

The report issued by the full committee recommended physics before chemistry. For them, the relative placement of physics and chemistry was not as important as the foundational nature of physics for other sciences. Physics had to precede meteorology, which was to be offered in the 12th grade. In their final report, the CoT recommended that since physics was a better representative of the “inorganic sciences” then it should be offered in the 10th grade (with chemistry in 12th grade). As a large percentage of students at this time left school after the 10th grade, the recommendation had the pragmatic objective of allowing all students to take physics—a “physics for all” plan.¹⁴

The CoT report provoked much discussion, and the education literature of the time was full of commentary and opinion about the relative placement of chemistry and physics. For example, in 1894 the Conference of Teachers of Chemistry meeting at the University of Chicago addressed the issue: “*Resolved*, that in the opinion of this conference, physics should precede chemistry in the high school curriculum.”¹⁵ The chemistry teachers argued that physics should logically come first because they considered it “foundational” to chemistry.

In 1899 a section of the New York State Science Teachers Association conference was devoted to “the sequence of sciences in the secondary school curriculum”¹⁶ and a range of views were expressed. John F. Woodhull recommended a chemistry-physics order based on the content of the science disciplines and the methods that were then used to teach them. According to him, the most important factor was the use of the laboratory for teaching science; chemistry experiments were simpler than physics experiments, and pragmatically he noted that it cost considerably less to equip students with chemical apparatus than physics apparatus. He also believed that chemistry was simpler than physics with respect to “training in thought power.”¹⁷ In agreeing with these observations about the difficulty level, William F. Langworthy noted that

the content of chemistry textbooks at the time was less difficult than the content of physics texts, but he recommended that physics be taught first for three reasons: a) physics was more appealing than chemistry; b) it was also “fundamental” to chemistry; and c) physics was “a more important branch of science for the average person.”¹⁸ Continuing the divergent opinions, Charles R. Barnes argued for a middle approach—that the order of presentation of the sciences was unimportant as each science could be presented logically at the appropriate developmental level. Ironically, he did consider that there was a logical structure to the sciences as a whole and that if there were limited science offerings at a school, then all students should take physics.¹⁹

Chemists Support Physics First

The Committee on College Entrance Requirements (CCER) was established to implement the recommendations of the CoT, and they made some far-reaching recommendations for the sciences.²⁰ The chemistry subcommittee, chaired by Alexander Smith, proposed that chemistry be taught in the final year of high school after physics. The physics section of the CCER, chaired by noted physicist Edwin Hall, made no recommendation about the grade placement of physics. The CCER formally recommended physics for 11th grade and chemistry for 12th grade. It also recommended that only one year of science should be required for graduation and that additional years would be elective, though they were quick to note that the one year, where possible, should be physics.

In 1902, Smith and Hall co-authored *The Teaching of Chemistry and Physics in the Secondary School*. In this book the arguments about the relative placement of physics and chemistry were fully articulated. Smith recognized that “the sequence of chemistry with reference to other subjects and the year in which it shall be placed are questions of great importance, since they affect profoundly the manner of the instruction and the amount that can be accomplished.”²¹ Smith’s arguments that “physics must come first” were:

- Physics was a prerequisite for chemistry.
- Preceding chemistry with physics was pedagogically economical, “since it will but little diminish the speed with which physics may be acquired, while greatly accelerating the progress of the pupil in chemistry.”²²

- Laboratory work in chemistry was at least as difficult as the laboratory work in other sciences and thus was no reason for placing chemistry before physics.
- He also disputed the argument that physics should be last because of the mathematics requirements, noting that only a small amount of the mathematics taught at the time (algebra and geometry) was needed in physics and that this could easily be taught by the physics teacher without having to delay the study of physics until the final year of high school.

In his half of the book, Hall did not address the topic of whether physics should precede or follow chemistry.

The arguments made by Smith and others were to no avail. Despite the widely held view that physics was “foundational” to chemistry, a Biology–Chemistry–Physics (B-C-P) order was eventually established. The changing demographics of schools, the appearance of new science courses, and the changing aims of education coupled with changing college admission requirements were all contributing factors. The B-C-P order has been the predominant, though frequently challenged, practice ever since. Numerous articles published over the last century questioned the B-C-P order and many repeated the familiar arguments about the foundational nature of physics to the other sciences.²³

An Obvious Yet Overlooked Issue – the Carnegie Unit

An issue neglected in the current “Physics First” debate is the matter of curricular time and credit awarded to high school sciences. The arguments proposed in the “First Physics First” movement were made before the widespread adoption of the academic credit system in schools. That there is even a debate about the grade placement of the sciences is a function of how U.S. high school science courses are administered as single-year, one-credit courses. It is the single-year time allocation that necessitates the sciences being taught in a particular order. This practice is:

- Unique to the United States. Debate about “Physics First” or “Capstone Biology” does not occur in other countries.

- Unique to the sciences. No other curricular area teaches its separate disciplines as fixed one-year courses. Imagine the obvious nonsense of teaching languages in a Spanish–French–Latin order with students completing the study of each language in a single year.²⁴

Historically, there were debates about the wisdom of having only single-year science courses. Indeed, both Smith and Hall recommended that if their subjects were to be taught before the junior year in high school then they should be multiple-year classes. Given the size of the schools and the available resources at the time, requiring multiple years of each science was logistically impossible for most schools.

The development and widespread adoption in the early 1900s of the Carnegie unit as the educational “coin of the realm” confined the sciences to the curricular practices of the time, i.e., the sciences became firmly fixed as single-year courses. For example, in 1909 the College Board unit in physics was redefined to be “120 hours of 60 minutes each” (the Carnegie unit) and “time spent in the laboratory shall be counted at one-half its face value,” and this is essentially the practice of teaching introductory physics today one hundred years later.²⁵ Despite the incorporation of much more physics into the high school program (e.g., all of modern physics), its time and credit allocation have not changed.

Administratively, the Carnegie unit was dramatically successful, bringing order to the curricular chaos at the turn of the 19th century. The Carnegie Unit expanded into all areas of education and became so ubiquitous that it is difficult to even consider American education without it. That U.S. high school curricula are organized around the Carnegie unit is the biggest stumbling block for the “Physics First” movement in that it polarizes high school physics into *either* a 9th-grade conceptual course *or* into a 12th-grade more mathematically sophisticated course. Proponents of 12th-grade physics argue that the 9th-grade course is “Physics Lite” and not really physics, while proponents of “Physics First” argue that the 12th-grade course is “Physics Heavy” and more of an exercise in applied math. Neither side seems to have considered the third option, recommended by Smith and Hall, that introductory high school physics

should be more than a one-year course, which should receive more than one credit as do all other nonscience academic subjects in high school.

Indeed, the limited time and credit allocation is the ultimate problem facing U.S. high school physics. Physics is a 21st-century subject confined to a 19th century curricular time allocation. We would suggest that high school introductory physics needs parity with other subjects. It should be at least a two-year, two-credit course and physics teachers should engage administrators and their “credit-rich” teaching colleagues in the debate as to where the time will come from. The first debates about “Physics First” included serious discussions about the time allocated to learning physics. It is time to return to this issue.

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