History and Trends in U.S. High School Science Course Taking

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This entry describes high school science course taking in the United States (U.S.). High school science course taking refers to the selection, enrollment, and completion of science-related coursework during grades nine through twelve. It encompasses both the timing, quantity, and the rigor (or level of challenge) of science courses. Science course taking in high school includes both foundational or core courses like biology, chemistry, physics, and environmental science. Students may also take advanced science courses such as Advanced Placement (AP), (International Baccalaureate (IB), career and technical education (CTE) or applied, and dual credit or dual enrollment science courses. Some advanced courses meet core course requirements (e.g., AP Physics). This entry focuses on core science course taking, and the distinction between core or advanced core is beyond its scope. A discussion of CTE and dual credit or dual enrollment science course taking is also beyond the entry's scope. The significant variability in core high school science course taking and historic unequal distribution of opportunities highlights the need for ongoing monitoring of factors influencing course taking to promote equity in access and outcomes. This entry presents a brief history of standards and graduation requirements surrounding high school science course taking, then briefly reviews science course pathways classifications and current trends in course enrollment and completion. A review of current trends in the context of historical developments can help the high school science education policy and practice field take stock of some of the factors that influence current patterns. The entry is written with a lens towards broadening participation in science, technology, engineering, and mathematics (STEM) fields and equity.

high school science course taking | STEM equity | science standards | STEM access | broadening participation

Monitoring trends and inequities in high school science course-taking has been a critical task for many decades as a national priority has been to strengthen pathways to STEM fields [1][2][3][4]. Although high schools in the U.S. tend to follow a biology–chemistry–physics core science course sequence, scientists, science educators, and researchers do not have consensus on science course sequences [5]. Up until the early 1900s, physics typically preceded chemistry in schools that offered both subjects, and this was the recommendation of national curriculum review committees convened between 1893 and 1899. By the early 1900s, with biology formally becoming a single course, committee recommendation had biology first in the sequence and chemistry and physics following in no specified order. Between 1924 and 1932, committees recommended that chemistry, as a more abstract science, be taught during the final year of high school with biology or physics preceding in any order. By 1959, following the predominant practice, biology first became the recommendation followed by chemistry and then physics [5].

The current course sequence among the core sciences in the U.S. has been shaped by customary practice in schools. However, a small, emerging body of research has found that having students take physics in the ninth grade promotes a stronger science course taking trajectory and can be beneficial for success in mathematics [6]. Physics educators argue that the subject's content is the foundation for biology and chemistry. Physics, they posit, is an intuitive subject connecting students' lived experience with everyday phenomena, which can enhance the learning of physics content. Opponents to physics first cite the prerequisite experience in algebra I to sufficiently master physics in ninth grade. For proponents, the movement of algebra I or integrated mathematics course taking in eighth grade and the option to have tiers of ninth-grade physics aligned with students' prior mathematics preparation make physics first an achievable goal. Implementation of an alignment between algebra I course taking and ninth-grade physics has proven a challenging undertaking [7]. Notwithstanding, research finds that students who take physics in ninth grade later take more challenging science courses in high school [8], score higher on AP and standardized tests, and have increased interest in STEM careers [6]. Schools adopting a physics first policy have achieved greater gender and racial balance in science course taking [6].

The history of science education in the United States reflects broader trends in education reform and economic shifts. In the 1980s, the release of the A Nation at Risk report highlighted the need for rigorous science education to prepare students for global competitiveness [9][10]. Since then, science course taking has increasingly been a focal point of education policy and standards movements, with calls for more students to engage in higher levels of science.

National Science Standards

Over the past three decades, a number of standards-setting efforts have influenced the state of high school science education in the U.S. [11]. Aspects of the content standards are highlighted here to indicate any shifts in science content emphasis that might influence science course taking. The American Association for the Advancement of Science (AAAS) published Project 2061: Science for All Americans (SFAA) in 1989 [12] and Benchmarks for Science Literacy in 1993 [13]. Combined, the two documents aimed “to set out the vision for what all Americans should know in science” and map learning outcomes across the grade span ([11], p. 77). The National Science Teachers Association (NSTA) published Scope, Sequence, and Coordination (SS & C) in 1989 and later Content Core in 1992 [14]. The documents were focused on science education for grades six through twelve, recommended content to be taught each grade, and introduced the idea of coordination of content across biology, chemistry, Earth and space science, and physics, as well as the need to revisit concepts periodically and in increasing depth (i.e., spaced learning) [11][14]. Although the AAAS and NSTA standards documents were widely circulated and frequently used to guide state standards, the two later science standards efforts—the National Research Council’s (NRC) National Science Education Standards in 1996 and the Next Generation Science Standards (NGSS) in 2013—became most influential.

The National Science Education Standards offered a comprehensive framework that outlined clear goals for K–12 science education [11][15][16]. It emphasized a shift from rote memorization toward deep understanding of scientific concepts, the importance of inquiry and hands-on learning, and the need for students to develop both content knowledge and the practices of scientific thinking [15]. The National Science Education Standards also integrated standards for content, teaching, assessment, professional development, and were intended to be mutually reinforcing [15]. Although these standards were not federally mandated, they provided a research-based framework that many states and school districts looked to when revising their own science standards and curricula.

With respect to high school science course taking, the National Science Education Standards do not prescribe a fixed sequence or a rigid set of courses for high school science. Instead, they provide a broad framework. The content standards for grades 9–12 followed the same content domains as for the earlier grades—science as inquiry, physical science, life science, Earth and space science, science and technology (including technological design), science in personal and social perspectives (including environmental science), and history and nature of science [16]. In contrast to the standards for the earlier grades, integration between the science disciplines was not emphasized (though not discouraged either). The standards also emphasized equitable access to science education and equity in science education policies [16].

The Next Generation Science Standards (NGSS) are currently the most widely adopted national science standards—thirty-nine states and the District of Columbia adopted or used NGSS to inform their standards by 2018 [17]. NGSS were developed by a coalition of 26 states and the NSTA, NRC, AAAS, and the Achieve non-profit organization. The NGSS detail model course maps for middle and high school [18]. The high school course models are the focus of this section. NGSS provide for both standard and accelerated science course pathways in high school, regardless of whether there are coordinated sequences with feeder middle schools. NGSS are organized around performance expectations consisting of content (i.e., disciplinary core ideas), practices (i.e., science and engineering practices), and cross-cutting concepts as the priority and not course sequencing. The performance expectations are organized within four domains—physical science, life science, Earth and space science, and engineering, technology, and applications of science. However, NGSS organize course mapping around year-long biology, chemistry, physics, and Earth and space science as the most common science subjects in high schools across the country [19]. NGSS also consider these four courses as foundational to high school science course-taking [18]. The courses map to the domains model consisting of physical sciences and life science, which organize the disciplinary core ideas, a key focus of NGSS [19]. The NGSS emphasize scientific inquiry and cross-cutting concepts, encourage a more integrated approach to science education, and weave in engineering performance expectations in all core courses [19]. NGSS also map options for accelerating science course taking to AP science courses through concurrent or rapid sequential scheduling, but in all models the three or four foundational courses are included [18]. For example, a student may take two core courses in ninth grade as semester-long instead of year-long courses and complete a third course in the first half of their tenth-grade year. Concurrent scheduling requires careful alignment of performance expectations and disciplinary core ideas throughout the progression of courses [18].

As apparent in the various science standards influencing science education in the U.S., biology or life sciences, chemistry, physics, and Earth and space have been consistent core science content. Environmental science was less prominent as a distinct core content area in earlier standards efforts, but was reflected in science in personal and social perspectives in the NRC standards. In NGSS, environmental science is reflected in “Earth Systems”, “Weather and Climate”, and “Human Sustainability” within the Earth and space science domain [20][21] and often in cross-cutting concepts.

Science Graduation Requirements

States’ science graduation requirements further shape science course taking in ways that do not necessarily reflect expectations apparent in the standards. Leading up to A Nation at Risk in 1983, educators viewed insufficient and non-academic course-taking patterns as a large part of the problem of underachievement nationally [22]. Following A Nation at Risk, the National Commission on Excellence in Education recommended increased graduation requirements in English, math, science, social studies, and computer science. For science, the commission recommended that secondary students be required to take three years of science for high school graduation. The commission did not specify the science courses to be taken as part of the recommendation. Although the goal of the committee was to increase achievement in science and other subject areas, the recommendation only targeted increased course taking under the hypothesis that increased science course taking should lead to increased credit attainment, which they hoped would have generated gains in science achievement.

In Teitlebaum’s [22] analysis of the influence of the initiative to increase graduation requirements using National Educational Longitudinal Study of 1988 (NELS:88) data, he found that twenty-six percent of students were in schools requiring three years of science course taking for graduation. Greater proportions of Black (26.8%) and Latinx (25.3%) were in such schools compared to the proportions of White students (24.5%), Asian (22.4%), and Native American (14.8%) students. The percentage of students in schools requiring at least three courses in science was greater for the lowest quartile of schools’ average socioeconomic status (26.0%), urban areas (27.1%), and the northeast (47.6%). Among students in schools requiring three or more years of science, Black students were about 0.6 times more likely to have satisfied the science requirement than White students. No other racial/ethnic comparisons were statistically significant. Teitlebaum’s [22] results showed that schools across the nation did not necessarily adopt a minimum graduation requirement of three years of science. However, students in schools that adopted the science requirement earned 0.38 more science credits on average, compared to students in schools who did not adopt the minimum requirement. Teitlebaum [22] found a nine-percentage-point difference in the percentage of students completing a mid-level or advanced science course in schools requiring three or more years of science compared to students in schools not having the requirement.

States have increasingly moved towards requiring at least three years of course taking in science. Based on a report from the Institute of Education Sciences (IES), as of 2005, 23 states required students to complete three or more years of science to graduate [23]. Twenty states required 1–2 years of science for graduation. The remainder of the states did not have data in the referenced report [23]. According to the Education Commission of the States 2023 compilation of states’ high school graduation requirements, 39 out of 50 states and the District of Columbia (76%) require students to complete at least three years in science, while the 8 states require fewer than three years of science. The remaining states do not have statewide graduation requirements, or the science requirement falls within a single STEM requirement [24]. In taking fewer than three years of science, it is unlikely that those students would encounter the full disciplinary science core during their high school tenure. Reports coming out of various initiatives across the country (discussed later in the entry) provide insights into the results of science course-taking patterns and changing graduation requirements.

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