General Education Across Top Tech Universities in the USA (in STEM era)

Yuge Tang[1,*]

[1] Chinese Language and Literature, Northwest University, Xi'an, 710127, China

*Corresponding author. Email: tyg771628347@qq.com

Abstract. General education is a topic that cannot be ignored in higher education in many countries around the world today. In particular, American higher education, especially in the fields of science and engineering, continues to lead globally, and general education is an indispensable part of undergraduate education in the United States. Based on searching on 3 top tech universities, this paper primarily explores the educational goals, curriculum design, and assessment mechanisms of general education in science and engineering universities. which can explore the cultivation of students' humanistic quality. At the same time, there is also an emphasis on the development of students' professional careers and the compromise on social employment.

Keywords: General Education, curriculum, Technology, University, USA

1 Introduction

Since the 20th century, the most mainstream approach to the education goals for overall student development has been general education.[1] Zhou Guangli stated, "General education comes from classical liberal education. The concept of liberal education originated from ancient Greek and Roman times. The "liberal" in liberal education refers to the corresponding political and economic freedom... Liberal education was a type of education suitable only for "freemen," or, as the 19th-century British would say, a gentleman's education, as opposed to the type of education suitable for slaves and craftsmen. Since freemen are only a minority in society, liberal education as a stage of higher education is a privilege of the few."[2] Therefore, "liberal education" does not possess the emphasis and grasp of the entirety that "general education" does, and experts are always in dispute over the definition of "liberal." General Education, as a unique educational philosophy and practice in the United States, is both related to and distinct from ancient Western concepts like liberal education and liberal arts education. [3] James Bryant Conant (1995) stated in the Red Book, "The core of general education lies in the transmission of liberal and humanistic traditions, integrating individual emotional experiences with social practice, to promote students' moral and ethical understanding of events." [1] In

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20th-century America, the target audience of general education was all citizens educated within this system. Some experts overly emphasized their specific disciplines regarding the goals of "liberal education." In 1941, James Bryant Conant, through his report to the committee and later in the Red Book, used the term "general education" instead of "liberal education." This shift highlighted that the goals of such education should target a broader audience—namely, all educated citizens—and should emphasize the overall social and cultural totality of the educational objectives, thus de-emphasizing the independence of individual courses' disciplines. Boyer proposed: "The ultimate purpose of general education is to provide every student with the opportunity to discover the common experiences of humanity in an era of specialization, enabling them to better understand themselves, society, and the world in which we live."[4]

The USA has the world's strongest Science, technology, engineering, and mathematics (STEM) majors. The education they receive in schools is not just about specialized majors and fields, but whether they truly possess the comprehensive qualities required to shoulder corresponding social responsibilities is closely related to non-major education in higher institutions. [5] According to the data of 2024 Forbes list, it can be seen that 8 of the top 20 billionaires are tech giants from the U.S. Most of them graduated from U.S. polytechnic colleges or comprehensive colleges with STEM majors [6]. Regarding employment, according to data from PayScale in 2023, schools with a higher proportion of STEM graduates also perform more strongly in graduate salary rankings.[7] We can understand this to mean that in the global market and American society, STEM graduates are more likely to acquire social resources and will continue to hold an advantageous position in the long-term evolving tech market. Do American STEM graduates have the necessary skills to drive positive social development in high-quality resource positions?

This paper primarily studies the general education in science and engineering universities in the United States. It does so by comparing the educational goals, curriculum structure, and evaluation mechanisms of the general education/core courses at the top three universities for undergraduate engineering programs as ranked by us.news2024. MIT is ranked first in undergraduate engineering programs by us.news2024 and holds absolute strength and reputation worldwide. Caltech is tied for third place in us.news2024's undergraduate engineering program rankings, making it the highest-ranked institution in California's unique educational system. Georgia is also tied for third place in us.news2024's undergraduate engineering program rankings and is the most employment-oriented institution with the lowest tuition fees among the top-ranked science and engineering schools. From the names of the institutions, the rankings in science and engineering fields, and the proportion of STEM majors, it is evident that all three universities are absolutely dominated by science and engineering disciplines. [8] The significance of this study lies in comparing the general education courses of these three science and engineering universities, which provides a clear view of how comprehensive qualities are nurtured in the STEM field in the United States, and it also focuses on the subsequent development of talent in research and the job market.

2 Comparison Among General Education Curriculum Systems

2.1 Educational Objectives

In any educational program, having a clear educational objective plays a vital guiding role in the specific curriculum setup. It establishes the principles for the types of courses and the implementation of the teaching plan. These three universities all have clearly defined objectives for their general education, which are displayed on their official websites.

According to the official MIT website "The undergraduate programs at MIT are designed to help students develop the knowledge and capabilities needed to meet the challenges of modern society. An MIT education joins the power of a specific discipline to a concern for social values and goals. In addition to developing expertise in a given field, undergraduates are encouraged to take advantage of the opportunities for broad learning at MIT and to become creative, intellectual leaders and problem solvers whose passion for learning is lifelong."[9] It can be summarized that MIT's general education goals mainly aim to cultivate students' ability to have a global perspective, to integrate into and lead social progress, as well as their capability and sustained enthusiasm for technological innovation.

According to the official website "All Caltech students, regardless of their option, complete the same core curriculum. Our faculty designed the core with one thing in mind – making you a better scientist." "take a course in every field of basic science. "Caltech emphasized in core curriculum, it be designed very hard "to take the best and the brightest STEM minds in the world and challenge them beyond what they believe is possible". Through the core curriculum, you'll learn to solve thorny, complex problems. You'll also learn how to collaborate with fellow scientists and communicate your ideas effectively. And more than anything, you'll see how everything you learn at Caltech is interconnected." [10] The core objective of Caltech's core curriculum can be summarized as cultivating scientists, with students gaining the ability to solve difficult and complex problems, a positive attitude in facing challenges, and strong communication skills for teamwork through their studies.

According to the official website "The USG core curriculum, Core IMPACTS, is designed to ensure that students acquire essential knowledge in foundational academic areas and develop career-ready competencies."[11] It can be summarized that the core curriculum of USG focuses on developing students' top-notch academic research skills, enabling significant progress in their future careers.

The comparison shows that the three schools have different emphases in their general education (core courses)—MIT focuses more on cultivating students' outlook on the world and future developments, primarily emphasizing innovation capability; Caltech places greater importance on training scientists within the research system; while USG aims to develop strong research skills that are versatile and sustainable in both employment and research fields. However, on common ground, we can see that top science and engineering universities all prioritize cultivating students' long-term development capabilities and perspectives in the STEM fields.

2.2 Curriculum Content Setup

General Education (core curriculum) at all three schools includes basic courses in Physics, Chemistry, Biology, and Mathematics; Humanities, Arts, and Social Sciences; Laboratory Science courses; and Academic Writing courses.

The General Institute Requirements at MIT are divided into four main parts: STEM, humanities and social sciences, restricted electives, and laboratory components. The STEM component includes elective courses in chemistry, physics, math, and biology, totaling 6 courses; the humanities and social sciences component includes anthropology, arts, and social sciences, requiring a total of 8 courses, with at least 2 of those being communication-intensive; the Restricted Electives in Science and Technology require 2 courses; and the laboratory component consists of 1 independent course, which requires at least 12 hours of instruction to be completed within two years.[9]

Caltech refers to its general education program as the core curriculum, which includes sciences, humanities, and social sciences. The focus of the first year of study is on core requirements, with fixed course requirements that must be completed by the end of the first year, which include: at least 27 hours of mathematics (covering Multivariable Calculus and Linear Algebra); at least 27 hours of a yearlong physics course; 15 units (classes) and 6 units (lab) of chemistry; and at least 9 hours of biology. Additionally, it includes: Menu Class: 9 units (subjects include Astronomy, Environmental Science and Engineering, Energy Science, Geosciences, Information, and Logic); Additional Introductory Lab: 6 units (multiple options); Computer Science: 9 units (Introduction to Programming)Scientific Writing: 3 units; Humanities and Social Sciences: 36 units in Humanities, 27 units in Social Sciences, and 36 additional units in either Physical Education: 9 units，In all, it was completed in two years. [10]

The core curriculum of USG includes seven areas, labeled A through F, with A1 being the Communication Outcomes area, Courses that address learning outcomes in writing in English, At least 6 hours; The A2 area is Quantitative Outcomes, Courses that address learning outcomes in quantitative reasoning, At least 3 hours; The B area is Institutional Options., Courses that address general education learning outcomes of the institution's choosing, At least 3 hours; The C area is Humanities, Fine Arts, and Ethics, At least 6 hours; The D area is Natural Science Mathematics, and Technology, At least 7 hours. At least 4 of these hours must be in a lab science course; The E area is for Social Science, Courses that address learning outcomes in the social sciences, At least 6 hours; The F area is for Lower-Division Major Requirements, 18 hours.For students in STEM and non-STEM majors, the math requirements in Area A2 are also different[11].

Table 1. Comparison among general education content in MIT, Caltech, Geogria

School/Course Type	STEM	Humanities &Arts &Social Sciences	Writing	LAB	Other

MIT	Mathematic, Physics, Chemistry, Biology	Anthropology, Art, Social Sciences	communication-intensive	Laboratory Requirement	Restricted Electives in Science and Technology
Caltech	Mathematics, Physics, Chemistry, Biology, Computer Science	Humanities and Social Sciences	Scientific Writing	Additional Introductory Lab	
USG	A2：Quantitative Outcomes D：Natural Science Mathematics, and Technology	E：Social Science C：Humanities, Fine Arts, and Ethics	A1：Communication Outcomes		B：Institutional Options

2.3 Student Evaluation

Evaluation is a feedback mechanism that can help schools promote updates to curriculum design and enhance students' self-motivation.“Recommendations are offered for evaluating three aspects of teaching:planning, implementation, and results. ”[12]

The requirement of MIT is to be recommended for the degree of Bachelor of Science, students must have attended MIT not less than three regular academic terms, which ordinarily must include the term of graduation. In addition, students must have satisfactorily completed a program of study approved in accordance with the faculty regulations, which include the General Institute Requirements (GIRs) and the departmental program of the Course in which the degree is to be awarded. Students must complete the course requirements specified in the program, and they can only obtain a Bachelor of Science after passing review by the departmental teaching and research groups and getting their GIRs applications approved. [9] Caltech's 1st Year Grading Policy has specific requirements regarding the subjects and credits that need to be completed for the core courses in the first year, and testing and class placements

will be conducted after the courses conclude. First two terms at Caltech, your introductory core courses will be graded Pass/Fail (P/F).[10] The USG requires that all courses in Areas A – E must be taught at the collegiate level and be broadly focused.They must clearly address the general education learning outcomes of the institution. They must be consistent with the USG's mission and strategic plan.[11] By comparing the official websites of the three schools, we find a commonality: that is, all students in every major must complete the university-designated general education (core curriculum) requirements during the first two years of their undergraduate studies. The difference is that MIT assigns different types of courses for review by different academic committees in the second year, while Caltech has fixed requirements for courses and credits in the first year.

3 Conclusions

We can see that the general education (core curriculum) programs at these three top science and technology universities follow the tradition of general education established by the "Red Book" in American universities after World War II. As Lin Jian stated, "Most world-class universities do not distinguish between majors in the early undergraduate years and implement broad-based education during the general education phase. This serves two main purposes: first, it helps students cultivate and discover their own learning interests and strengths during the broad-based general education process, which benefits their personalized development； Secondly, it inspires students to view the objective world from different perspectives, to identify problems and think critically about them, laying a broad foundation for professional education in general education." [13] Through research on three schools, we can see that during the first to second years of undergraduate studies, students only take general education courses. At the same time, from the course offerings, it can be observed that the curriculum not only includes the cultivation of humanistic qualities through humanities and social sciences but also enables students to learn foundational knowledge and research skills across various STEM disciplines comprehensively.

However, in reality, the effectiveness of general education in American colleges is often unsatisfactory. The American Association of University Professors even presented a report with a pessimistic tone: "The Decline of General Education: 1914–1993 "[15].We can foresee that in today's context of strong development in STEM fields, the pursuit of broader personality development through general education still faces an ideological conflict with the disciplinary systems of higher education institutions and the inevitable profit-driven orientation of students when it comes to employment. Wang Xiaoyang summarized in his paper that this conflict arises from both the pressure on teachers due to specialization and the career-oriented mindset of students.[15] Paul Hanstedt, an English professor at Roanoke College in Virginia, points out that the biggest problem with general education is not the courses themselves, but rather the lack of understanding among students regarding the importance of these courses. Students perceive the requirements of general education as irrelevant. On the other hand, at prestigious research universities, it is common for

over 90% of students to pursue graduate or professional degrees, and they desire to enter professional courses as soon as possible, viewing general education courses as obstacles to overcome.[16]

The current cultivation goals set for students by general education originate from a focus on the development of character and the spiritual aspects of education, which correspond to a curriculum largely centered around literature, philosophy, and social sciences. However, at today’ s American universities with a focus on science and technology, general education courses include a significant number of mandatory STEM-related courses and assessments from the beginning of enrollment, while humanities and social sciences courses are somewhat diminished. American higher education historian Visser believes that there are two major differences between liberal education and science education, science education pursues knowledge, while liberal education pursues the meaning of knowledge; science education aims to cultivate experts, while liberal education aims to cultivate free-spirited people [17] The pedagogies of the two are also very different. Science education emphasizes lectures, field research and experiments; liberal education emphasizes extensive reading, critical thinking and creative writing.[18] The general education (core curriculum) of American science and engineering colleges and universities mandates students to study a large number of comprehensive STEM foundation courses, which is actually to lay the foundation for students' subsequent professional studies, while at the same time, an appropriate amount of humanities and social sciences courses are still mandatory, which also integrates and makes up for the contradiction between the two, and is a strategy based on the reality of education and scientific research needs in science and engineering.

References

1. General Education in A Free Society, Harvard Committee., 1995, p.17
2. On the Appropriateness of Higher Education: Research on the Divergence and Integration of General Education and Professional Education, Zhou Guangli, 2015
3. Models, Challenges, and Countermeasures of General Education in American Universities, Wang Xiaoyang and Cao Shengsheng, 2015
4. On the philosophy of Higer Education, John.S.Brubacher, 1965, p.75~76
5. The Idea of A University, John.Henry.Neman, 1852
6. https://www.forbes.com/
7. Payscale - Salary Comparison, Salary Survey, Search Wages
8. US News Education | Best Colleges | Best Graduate Schools | Online Schools
9. General Institute Requirements < MIT
10. Core Curriculum - Undergraduate Admissions (caltech.edu)
11. Academic & Student Affairs Handbook | 2.4 Core Curriculum | University System of Georgia (usg.edu)
12. Pratt, D.D. Reconceptualizing the evaluation of teaching in higher education. Higher Education 34, 23–44 (1997). https://doi.org/10.1023/A:1003046127941
13. Multidisciplinary cross-fertilisation of nascent engineering professional construction,Lin Jian, 2017

14. Balch Stephen H and Rita C Zurcher. The dissolution of general education: 1914-1993 ［R］. National Association of Scholars, 1996.
15. General Education Models, Challenges and Countermeasures in American Universities, Wang Xiaoyang, 2015
16. Catherine Seraphin. “General Education Requirements What’s the Point?” Spring 2013 CollegeXpress.com.
17. The Rise of the Modern American University, Lawrence Visser, Peking University Press, 2011
18. On the New Three Centers : Concept and History - - One of the Research on SC Undergraduate Teaching Reform in the United States, Zhao Juming, 2016