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The Current State of STEM Education in the United States: Strengths and Shortcomings

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Abstract

STEM education (Science, Technology, Engineering, and Mathematics) has been revered for many decades for its potential to foster innovation, critical thinking, and problem-solving skills essential for the modern workforce. However, while the benefits of STEM are widely acknowledged, significant challenges remain in its implementation, particularly in addressing the needs of a diverse and evolving society. This paper explores both the advantages and the disadvantages of current STEM educational practices. Through a thorough review of existing research and empirical data, we identify key areas where STEM succeeds in providing baseline skills for a prolific STEM career, and also key areas where STEM education falls short, such as inclusivity, accessibility, and the integration of interdisciplinary approaches. We argue that for STEM to truly fulfill its purpose, it must undergo substantial improvements to better accommodate diverse populations and contemporary societal demands. Our findings suggest that a more holistic and equitable approach to STEM education is necessary, one that not only preserves disciplinary integrity but also promotes cultural relevance and broadens participation across all demographics. This research highlights and attempts to specify the urgent need for systemic changes to ensure that STEM education can effectively contribute to a more inclusive and fruitful society in the future.

Keywords: STEM Education, STEM Workforce, Women in STEM, Education curricula, Underrepresented Minorities (URMS)

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Introduction

The term STEM (Science, Technology, Engineering, and Math) was coined by the National Science Foundation to represent the four necessary spheres of education that the future economy would depend on. STEM education first began to gain traction when the American government realized how lacking the American population's education was in these areas of learning. After the Soviet Union first launched Sputnik (the first satellite) in 1957 the US rushed into further developing their education system and policies as they found it lacking compared to the Soviet Union. In 1958 the United States passed the National Defense Education Act (NDEA) which aimed to advance the areas of science, technology, mathematics, and foreign languages being taught at the time. The act encouraged postsecondary education as it would help boost the economy and help the United States catch up to the Soviet Union. Throughout the following years, the push for STEM education continued as the need for a more capable and educated workforce grew. More and more federal programs and funding initiatives were created to help support and grow the science and mathematics curriculum being taught. The publication of "A Nation at Risk" in 1938 by the US National Commission on Excellence in Education highlighted the insufficiency of the then-current education system and called for a reform in the educational standards and the enhancement of STEM education. Over the years, STEM only became more prominent. As STEM progressed, the world progressed with it, and countless innovations such as sustainable water filters, live virus tracking, and even ventilators led us to the world we live in today. And while many things have changed since then, STEM still plays a large role, especially in the United States. In today's day and age, STEM education is considered vital to preparing students with the necessary skills for the technology-driven world we live in today. However, the one-minded focus in STEM education has not been without its drawbacks. One notable criticism is the marginalization of the humanities, arts, and literature aspect of a well-rounded education. This approach is detrimental to students' education due to the importance placed on one aspect of learning and completely neglecting the equally important non-STEM facets that help develop their creativity, critical thinking, and awareness of the world. Adding onto that the unbalanced education leads to disparities in educational opportunities and those students who choose to pursue a non-STEM path face a disadvantage due to their lack of education needed to develop their particular talents and interests. Another critical issue is the persistent underrepresentation faced by women and minority racial groups(most commonly Blacks and Hispanics) in the STEM workforce. Despite some measures taken to improve the diversity and acceptance of these groups, they still face barriers that limit their contribution and advancement in their fields. The lack of consistent change in this system allows for the systematic alienation and inequality of these groups. To truly use STEM education to its maximum potential we must work toward a more integrated approach to education—one that prioritizes the humanities and arts as much as it does STEM. By placing importance on both sides of the educational spectrum students can gain a better understanding of the world and more tools at their disposal to be able to thrive in said world. Improvements in this domain along with efforts to increase minority representation will lead to a more inclusive, fruitful future for STEM Education and STEM careers.

Strengths of STEM Education

As the world progresses towards an increasingly technology-driven future, STEM education (Science, Technology, Engineering, and Mathematics) has become more than just a specialized field of study; it is a critical skill set for navigating the complexities of future advancements in medicine, technology, and various scientific disciplines. A strong foundation in STEM education empowers students to not only develop critical thinking and problem-solving abilities but also fosters creativity and the capacity to apply knowledge to real-world scenarios. By cultivating these competencies, STEM education equips students with the tools necessary to not only pursue their dream careers but to also effectively address the challenges that will accompany them.

With the availability of STEM scholarships, its relevance has demonstrably increased between 2008 and 2018, showing a heightened focus on research and analysis in STEM education (Li, Wang, Xiao, & Froyd, 2020). For example, within the year 2010, there was a sparse amount of recorded publications with a mere 16 research papers officially published regarding STEM education. However, a significant gap was recorded in the year 2018, with a staggering 230 publications, illustrating the sheer growth and popularity of STEM education since the base of its traction (Li, Wang, Xiao, & Froyd, 2020). Along with this, the inclusion of the International Journal of STEM Education in the SSCI in 2019, allowed for journals to "develop their own identity for publishing and sharing STEM education research" (Li, Wang, Xiao, & Froyd, 2020), thereby expanding the range and platform that STEM reaches across not only the U.S, but globally.

With the rising popularity of STEM education, STEM education has proven to be a viable form of learning new and complex skills that are needed in the upcoming frontier fields. For example, engineering prioritizes conceptual and procedural knowledge in order to excel in the necessary thinking, problem-solving, modeling, predictive analysis, and optimization skills that are foundational to the design process (Fan & Yu, 2017). Along with the many valuable skills that are taught within STEM curriculums, the form in which skills are taught is impressive in the idea of the student's memory retention. Subjects taught in STEM education prioritize kinesthetic learning, which is the 'hands-on' teaching of concepts or skills while straying away from the traditional, more strict form of learning. Rather than simply jotting down notes during lengthy lectures, kinesthetic learning values students to be able to not only visualize the concept that is presented to them but also increase their engagement and attentiveness through more interactive lessons. With this, the kinesthetic learning that STEM education offers provides a staggering "80 to 90% retention rate" compared to an underwhelming 5% from traditional methods of education (Baker College, 2021). With the combination of both the instructing of tangible skills as well as a strong base of memory retention, the capabilities taught by the STEM education curriculum along with its method of teaching creates a perfect environment for students to truly grasp the subjects that are presented to them, while also proving the ability for teachers to effectively teach the variety of simple and complex subjects that come with the careers in STEM.

Along with cognitive benefits and the effective educational tools that STEM education offers to advance a young generation of students, nations themselves have also found positives in educating their youth with STEM. For example, the International Council of Association for Science Education found that “Improving teaching and learning in STEM education has become an economic factor in developing countries, emerging economies, and in long-established economies” including the United States and the United Kingdom. On an international level, STEM education has the potential to “improve competitiveness in the global economy” (Ismail, 2018), as countries have the increased desire to improve their technologies to those who are actively pursuing a better grasp on STEM technologies. This indirectly creates an emphasis on both the United States’ education, but also the overall advancement of its technologies. With better technologies in STEM, vital fields such as medicine and engineering have the potential to invest in new futures, such as Genetic Engineering or even Aerospace engineering. All of these can greatly help any country's general health, convenience, protection, or knowledge by incentivizing groundbreaking technology. Not only this, but STEM Education has also helped with “curbing unemployment” (Ismail, 2018). By creating a workforce that is in high demand in a variety of different fields, while having widespread, increasing access to vocational schools, occupations in STEM subsequently skyrocketed. Students who decide to study the core subjects in STEM in college or vocational institutions can help “minimize workforce skill gaps” by keeping the working population up to date with advanced or ‘tech savvy’ technologies that have become rampant across occupations today (Horizon Science Academy Des Moines, 2021).

When considering the benefits of STEM education of advanced teaching, learning new skills, and stimulating economies, STEM education has become an important factor in the many developing STEM fields as well as the nation's overall economy. This significance and sentiment that STEM holds in occupations today are widely accepted by employers in the U.S. As evident in a survey conducted by the Business and Industry Advisory Committee (BIAC), it was found that "Employers most commonly believe that more emphasis is needed on science, technology, engineering, and mathematics (STEM) in national curricula" (Barcelona, 2014). This information is evident in Figure 1, shown below.

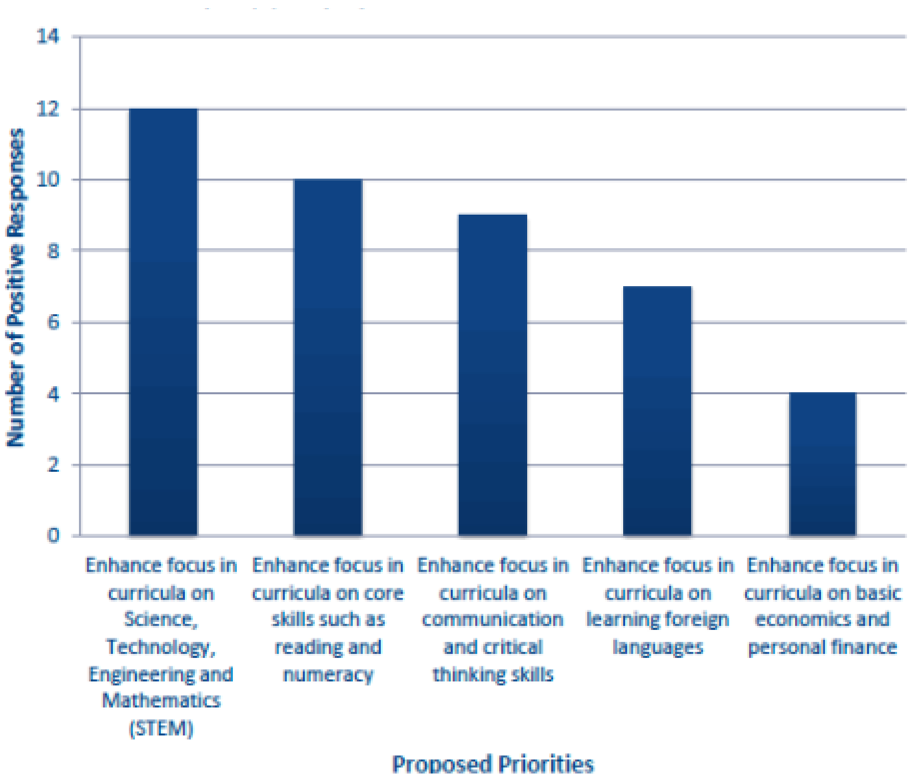

Figure 1. Survey of Employer's Priorities for Curricular Reform

Source: Adapted from "BIAC Education Committee Survey Synthesis Report", 2013, Business and Industry Committee, Retrieved from: https://curriculumredesign.org/wp-content/uploads/130605_BIAC_Education_Survey_PREMIUM.pdf

While the survey was conducted by the BIAC in 2014, its application was emphasized even more so with the immense growth of STEM fields. As of late, research by the U.S Bureau of Labor Statistics (BLS) has found that "employment projections show that occupations in the STEM field are expected to grow 8.0 percent by 2029" overshadowing the 3.7 percent growth for all occupations (Why computer occupations are behind strong STEM employment growth in the 2019–29 decade, Zilberman & Ice). For example, computer science occupations, a STEM field, are predicted to "grow about 3 times as fast as the average between 2018 and 2029 at 11.5 percent". This can be shown in the figure below.

Occupation title	Employment	Percent change	Employment change

	2019	2029	2019–29	2019–29
STEM occupations	9,955.1	10,752.9	8.0	797.8
Computer occupations	4,633.4	5,164.6	11.5	531.2
Engineers	1,810.1	1,879.1	3.8	69.0
Life scientists	344.8	361.4	4.8	16.6
STEM post secondary teachers [1]	294.1	308.8	5.0	14.7
Physical scientists	276.6	291.4	5.3	14.7
Mathematical science occupations	211.7	267.8	26.5	56.1

[1] Aggregate employment for 11 different STEM post-secondary teacher occupations.
Notes: Employment numbers in thousands.

Figure 2. The recent predicted change of employment in STEM occupations

Source: Adapted from "Why computer occupations are behind strong STEM employment growth in the 2019–29 decade", 2021, Zilberman & Ice, Retrieved from: https://www.bls.gov/opub/btn/volume-10/why-computer-occupations-are-behind-strong-stem-employment-growth.htm#:~:text=The%20U.S.%20Bureau%20of%20Labor,3.7%20percent%20for%20all%20occupations

As the growth of STEM fields is due to expand dramatically over the next decade, STEM occupations also provide students with job security as the average wage exceeds many other wages within the U.S. As presented by the U.S Labor of Statistics in 2023, the total median salary of non-STEM occupations reached $46,000, compared to the $101,650 that the STEM occupations withhold as seen in the image below. With factors such as rising housing prices and inflation, considering high education to high-paying jobs is an advantage for upcoming college students to implement alongside their career interests, passions, and goals. With STEM, there is a pathway for every student looking to invest in their future.

Occupation category	Employment, 2022	Employment, 2032	Employment change, numeric, 2022–32	Employment change, percent, 2022–32	Median annual wage, dollars, 2023
Total, all occupations	164,482.6	169,148.1	4,665.5	2.8	48,060
STEM Occupations	10,365.0	11,487.4	1,122.4	10.8	101,650
Non-STEM occupations	154,117.6	157,660.7	3,543.1	2.3	46,680

Figure 3. Median Annual Wage of Non-Stem Occupations vs. Stem Occupations in 2023

Source Adapted from: "Employment in STEM Occupations", 2024, U.S Bureau Labor of Statistics. Retrieved from: Employment in STEM occupations : U.S. Bureau of Labor Statistics (bls.gov)

With STEM, the future holds immense potential, fueled by the ongoing growth of curious young minds. This focus on science, technology, engineering, and mathematics equips students to become the innovators of tomorrow, and the ability to tackle global problems such as pollution, disease, and so much more. By fostering a skillset of inquiry and problem solving along with its effective teaching, STEM education carves a path towards a brighter, more sustainable future for humanity.

Drawbacks of STEM

While it is accurate to say that STEM education has proven to be a relatively successful implementation in educational curricula all across the United States, that is not to say that it does not have its shortcomings as well. Negatives of STEM arise just as prominently as positives of STEM, and these negatives need to be addressed in order to truly allow STEM education to flourish to its fullest potential.

Drawbacks of STEM branch into many different areas including but not limited to: problems in financing this education, poor student motivation or interest, and difficulty in integration(Hsu & Fang, 2019). Hsu & Fang argue that a big challenge of the integration of STEM education is implementing multidisciplinary subjects while maintaining the disciplinary integrity of all subjects(Hsu & Fang, 2019, p. 15). In other words, it is important to find a balance between both STEM and non-STEM subjects taught at school to provide a well-rounded education. Furthermore, Hsu & Fang also discuss the importance of assisting teachers in further developing their ability to facilitate STEM education in the classroom, emphasizing that the methods in which STEM is taught are a requirement for success(Hsu & Fang, 2019, p. 15).

Underrepresentation of Women in STEM Careers

A challenge STEM education has struggled to accommodate for some time is the relative underrepresentation of women. In particular, women have been lagging behind their male counterparts in participation in STEM-related careers for decades, despite doing just as well, and, in many cases, better than male students in science subjects both in elementary(primary) and after elementary(secondary) school(Xie, Fang, & Shauman, 2015).

Occupation	Percent who are women
Life, physical, and social science	46.7%
Computer and Mathematical	25.6%
Architecture and engineering	15.9%

Figure 4. STEM occupations and the percentage of employed women in these occupations; 2018 annual averages.

Source: Adapted from "Celebrating Women in STEM Occupations," 2019, U.S. Bureau of Labor Statistics. Retrieved from https://www.bls.gov/blog/2019/celebrating-women-in-stem-occupations.htm

While women account for the majority of graduates with social science and biology degrees in the United States and other industrialized countries, they remain underrepresented in most other STEM fields such as computer science and engineering (Xie et al., 2015). This information is supported by Figure 3 above.

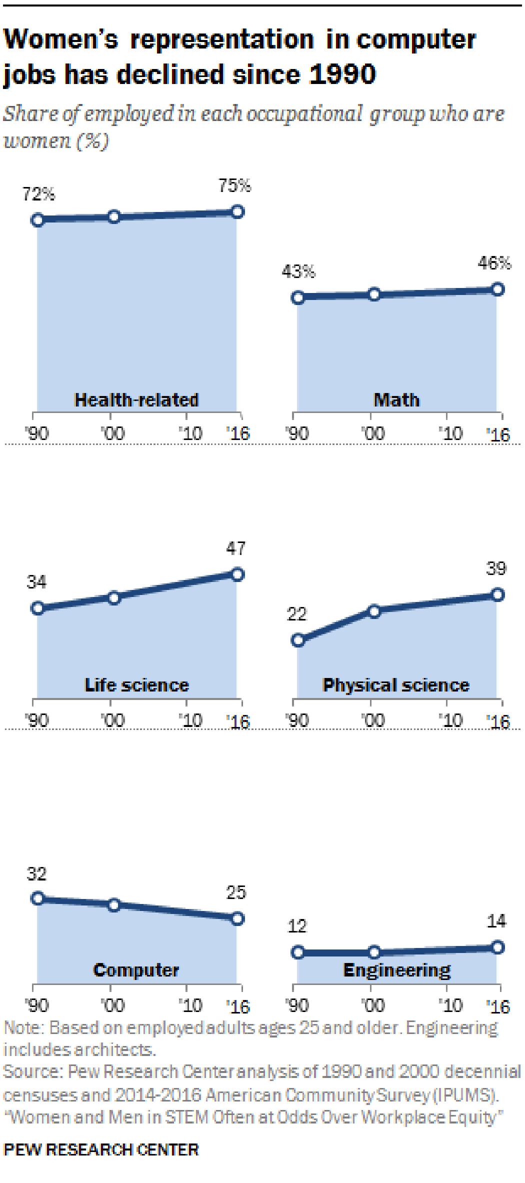

Figure 5. Shows the change in the percentage of employed women in various STEM fields from 1990 to 2016

Source: "Diversity in the STEM workforce varies widely across jobs," by K. Parker, 2018, Pew Research Center. Retrieved from www.pewresearch.org/social-trends/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Figure 5 illustrates how the percentage of women in the STEM workforce has changed over the past three decades. This further demonstrates the underrepresentation of women, especially in fields involving computer science and engineering. Notably, the percentage of women in computer science has decreased steadily since 1990, which is a big concern in regard to the representation of women in STEM.

The underrepresentation of women in STEM is— and has been— subject to question for many years. This has led to various assessments that attempt to explain this gender gap. Some theories based on possible sex-based predispositions argue that women, being biological childbearers, naturally are inclined to “prioritize family over work roles”(Xie et al., 2015, p. 12). This theory suggests that the role of women in not only the STEM workforce but the workforce in general is limited by the natural maternal instincts possessed by women. Similarly, another theory concerning sex-based predispositions argues the natural differences between men and women explain the gender gap. This theory attributes men's interest to problem-solving and innovation, while women’s interests are attributed to emotional connection and interaction(Xie et al., 2015). However, these theories are not supported, as research shows that “interest in STEM is highly responsive to environmental influences”(Xie et al., 2015, p. 12). This tells us that interest or disinterest in STEM is determined by factors in one’s environment such as the accessibility to STEM education, societal and cultural norms, exposure to STEM careers and role models, and competent and supportive learning spaces. This may explain why women in industrialized countries seem to be more engaged and involved in STEM.

Underrepresentation of Minorities in STEM Careers

Along with women, minorities have continued to be subject to underrepresentation in STEM. Even though the underrepresented minority groups of Blacks, Hispanics, and Native Americans have made significant improvements over the past few years, they continue to be overshadowed by Whites and Asians in STEM fields(Xie et al., 2015, p. 13). The race gap in STEM is influenced by numerous factors, including stereotypes, unequal access to resources, and a lack of representation. These challenges contribute to a scarcity of representation, and therefore, role models for URMS in STEM fields.

Similarly to women, studies indicate underrepresented minorities (URMs) express equal levels of interest as their White counterparts; however, in contrast to the former, URMs do not typically exhibit the same level of mastery(Xie et al., 2015, pp. 13-15). In elementary, middle, and high school, URM students tend to take fewer advanced math and science classes than White and Asian students, which may account for their underachievement(Xie et al., 2015, p. 14). URM students also fall behind in standardized tests but account for the majority of students who are in lower-level classes(Xie et al., 2015, p. 14).

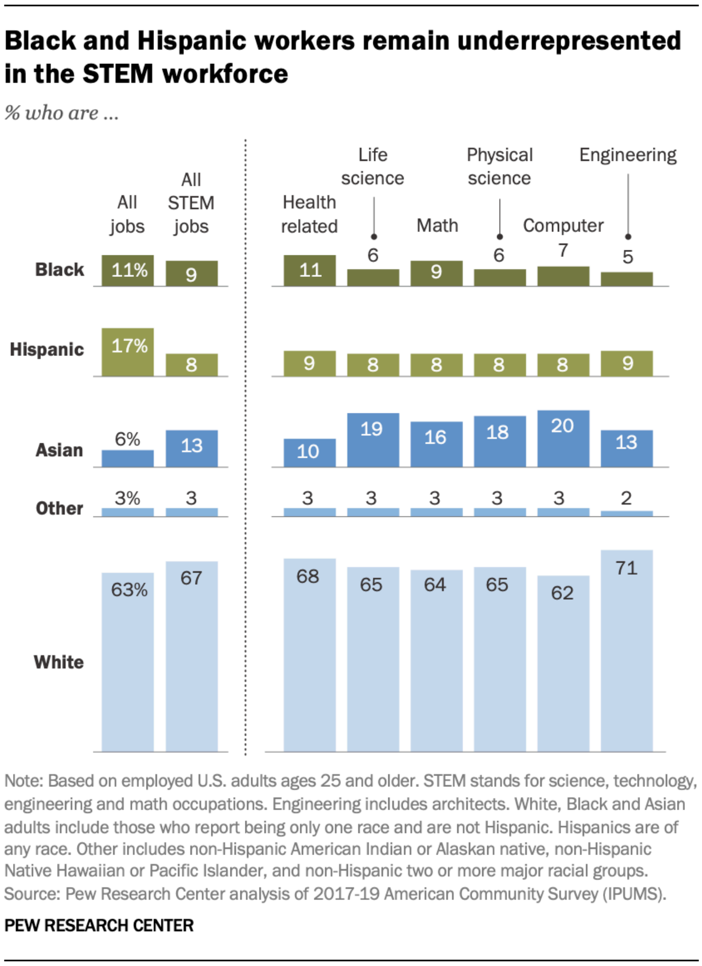

Figure 6. Shows bar charts illustrating the percentage of both the STEM and general workforce by race.

Source: "6 Facts About America's STEM Workforce and Those Training for It," by Brian Kennedy, Richard Fry, & Cary Funk, 2021. Retrieved from https://www.pewresearch.org/short-reads/2021/04/14/6-facts-about-americas-stem-workforce-and-those-training-for-it/

According to Figure 5, as of 2021, Blacks and Hispanics account for only 9% and 8% of all STEM jobs, respectively, which is significantly lower than their White and Asian counterparts, who represented 67% and 13% of all STEM jobs in 2021, respectively. Another notable statistic in Figure 5 is the fact that Whites and Asians each account for a higher percentage in STEM jobs than all jobs, but this is the exact opposite when it comes to Blacks and Hispanics. This could show current representation and role models' influence on prospective young people. Whites and Asians have more role models to look up to in STEM fields, which draws them toward these fields. In the opposite direction, the same is true for Blacks and Hispanics, who may be drawn more toward non-STEM occupations for similar reasons.

Another factor that plays into this is racism perceived by the minority groups in question. 62% of Blacks and 42% of Hispanics in STEM-related jobs report that they have experienced some type of discrimination based on their race(Funk & Parker, 2018b). However, the same can be said for 44% of Asians in STEM(Funk & Parker, 2018b). The topic of structural racism in STEM is one that must be acknowledged from many viewpoints before it can be used to make unanimous factual assessments.

Conclusion

Without a doubt, STEM Education has been a crucial addition to educational curricula not only in the United States but worldwide. Since the mid-1900s when science and technology began to gain traction, there has been a boom of jobs relating to these fields, now called STEM fields. The implementation of STEM Education in common school curricula in the United States has led to a nation in which young leaders have been given a platform to explore their interests to a higher degree. The United States's highly industrialized landscape and accessible, abundant resources greatly contribute to the proliferating STEM workforce.

The hands-on, kinesthetic learning approach in STEM leads to higher engagement and retention rates among students. Internationally, improving STEM education can enhance competitiveness and address workforce skill gaps. It also provides economic benefits by curbing unemployment and meeting the demand for a tech-savvy workforce. However, with its prominence come many challenges, such as those outlined in this article. Addressing these challenges is essential to shaping STEM educational programs and the STEM workforce into a more inclusive and fruitful environment, ultimately benefiting society to a higher degree. While the United States has made significant strides in STEM education since its introduction in the late 1900s, ongoing efforts are needed to break down barriers and open up opportunities across all demographics. To truly harness the potential of STEM education, it is crucial to invest in teacher training, normalize equitable access to resources, and foster a culture that encourages innovation and critical thinking. The global landscape demands not just an expansion of STEM fields but a reimagining of how education can adapt to the evolving needs of society. Ensuring that every student has the opportunity to succeed and contribute meaningfully to the world of tomorrow will drive our world to a brighter future in which all will flourish greatly.

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