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Is Science for All an Elusive Goal? Disparities in U.S. Science Education

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Introduction

Life in the twenty-first century is influenced by unprecedented developments in science and its technological applications. Virtual reality, artificial intelligence, self-driving cars, electric vehicles, 3D printed houses, space tourism, and wireless technology are quickly changing society. Considering the significance of science and technology calls for a science-skilled workforce have come from stakeholders from all domains of life (National Science Board, 2022). According to the U.S. Department of Commerce, workers in science, technology, engineering, and mathematics (STEM) play a significant part in generating new technologies, businesses, and revenue streams, significantly benefiting local and national economies (Noonan, 2017). Leading science and science education organizations such as the American Association for the Advancement of Science (e.g., "Project 2061") and the National Science Teachers Association (e.g., "NSTA Position Statement"), the NGSS Lead States (e.g., "Next Generation Science Standards") and funding agencies such as the National Science Foundation (e.g., "Robert Noyce Teacher Scholarship Program") have advocated that science is for all students, making repeated calls for preparing students of all backgrounds to pursue education and careers in STEM fields. According to Milgrom-Elcott (2022, para. 2), "…only a tiny fraction of our nation's population has the necessary STEM skills, knowledge, and agency. STEM inequities disproportionately affect young people of color, rural kids, children in poverty, and girls—and these inequities are magnified for young people who carry more than one of those identities." Inequality in socioeconomic status and science achievement continues to be a barrier to providing high-quality science education to all (Betancur et al., 2018), and U.S. science education seems to suffer from socioeconomic disparities. In this context, is science for all students an elusive goal remains an important question worth addressing.

Is Science for All an Elusive Goal?

There are several ways to address the question, is science for all students an elusive goal? Considering the significance of socioeconomic factors in almost all domains of human existence, this paper examines a few trends in science education concerning a well-established socioeconomic disparity indicator in K-12 education, the Free or Reduced-Price Lunch (FRPL). The National School Lunch Act of 1946 provides low-cost or free lunch meals to qualified students through school subsidies (Kosar, 2011). Through amendments, the act has undergone numerous revisions to enforce a variety of nutrition requirements, such as the addition of a larger portion of fruits and vegetables. The National School Lunch Program serves children in approximately 100,000 public and nonprofit private schools and residential childcare facilities with free or inexpensive lunches. During the 2019 fiscal year, the program served 4.9 billion lunches costing 14.2 billion dollars (U.S. Department of Agriculture, 2022).

According to the National Center for Educational Statistics (2023), high-poverty schools have more than 75.0 percent eligible students for FRPL, whereas low-poverty schools have 25.0 percent or fewer eligible students. Mid-to-low FRPL (25.1-50.0 percent) and mid-to-high poverty (50.1-75.0 percent) schools fall between these two categories. Further discussion is based on analysis of disparities in Per Pupil Spending, Technology Resources, Science Course Offerings, and Race and Ethnicity Distribution in FRPL Groups data reported by the National Survey of Science and Mathematics Education (NSSME) (Banilower et al., 2018; Banilower et al., 2013), U.S. Government Accountability Office (2017), and NCES (2022, 2023).

Inquiry-Based Learning, Per Pupil Spending and FRPL

In the current era of information and technology, where scientific knowledge is expanding daily, and technological advancements are happening at a rapid pace, education in STEM fields, which have a direct impact on every aspect of our lives, is essential for the future of societies (Abdi, 2014; Karamustafaoglu, 2010). Science educators and researchers have advocated for an inquiry-based learning approach to developing science literacy. Inquiry-based learning represents both the practice of scientists and the most effective method for students to learn science (Sheninger & Devereaux, 2013) by promoting scientific investigations focused on observation, experimentation, and reasoning (Chiappetta & Adams, 2004).

Schools need laboratory equipment and consumable supplies to engage students in inquiry-based science education. In schools eligible for FRPL, there is a disparity in the median amount of money spent per pupil between the highest quartile and the lowest quartile in 2018 and 2012. The per pupil spending adjusted for inflation (Kumar, 2022) shown in parentheses also highlights this disparity. In 2018, the spending per pupil (Banilower et al., 2018), in the highest quartile amounts to $2.05 ($1.69), and in the lowest quartile, $5.62 ($3.90). In 2012 (Banilower et al., 2013), spending per pupil between the two quartiles was $1.54 and $3.56, respectively. An increase of 33 percent in the highest quartile and 58 percent in the lowest quartile highlights a significant socioeconomic disparity. Stakeholders in education must address this disparity if science for all students is truly a priority, as frequently stated by school leaders, legislatures, and business leaders.

Technology Resources and FRPL

The increasing trend in the use of technology in school provides a means to enhance student learning. The inclusion of technology in science education assists students with learning essential skills like problem-solving, critical thinking, and teamwork. Technology enables students to access information and interact with data often integrated during inquiry-based learning.

According to NSSME (Banilower et al., 2018), the availability of instructional technology resources (probes/sensors, calculators, computers) for science instruction considerably differs between schools in the lowest FRPL quartile (62 percent of classes) and the highest FRPL quartile (46 percent of classes). As Nagel (2020) noted, the disparity in educational technology has a history of socioeconomic connections, and it became more visible during the pandemic. Students in a northwest U.S. district with an average household income of around $100,000 and about 5.7 percent of people living in poverty had faster educational technology access when compared to another district in the same state with an average household income of less than $60,000 and about 16 percent living in poverty. It is a shame that such gaps exist in a prosperous nation.

Science Course Offerings and FRPL

Advanced placement and international baccalaureate courses prepare students for college by offering challenging and engaging academic work. The benefits of advanced coursework include improved student self-esteem (Francis et al., 2019), higher engagement in studies with fewer absences and suspensions (Patrick et al., 2020), and increased likelihood of double majoring and taking advanced math and laboratory science coursework in college. Additionally, there is a higher chance of graduation, college attendance, and degree attainment for high school students who take advantage of advanced coursework (Montell, 2020).

Based on the U. S. Government (2018) report on K-12 education, there is a disparity in the offering of high school courses in STEM disciplines between students in the high FRPL (75-

100%) and low FRPL (0-24%) schools. High-poverty schools are less likely to offer the Science (Physics, Chemistry) and Mathematics courses that most colleges expect their students to have in high school. This is a serious concern when accounting for considerable differences in demographics between high and low-poverty schools.

Teacher Background and FRPL

Science content knowledge – the facts, theories, principles, ideas, and vocabulary – is an important essential component of teacher effectiveness. Much research suggests a direct correlation between effective teaching and teachers' science content knowledge (Robinson, 2017).

According to estimates by the National Survey of Science and Mathematics Education (2018), 52 percent of classes in the highest FRPL quartile are taught by teachers with substantial science backgrounds or have completed at least three advanced science courses compared to 66 percent of classes in the lowest FRPL quartile (Banilower et al., 2018). This discrepancy in teacher background in science is another clear sign of the ongoing socioeconomic disparity in science classrooms.

The Science Knowledge Gap and Race and Ethnicity Distribution in FRPL Groups

Studies consistently report that students from disadvantaged backgrounds – such as low socioeconomic families, members of specific minoritized groups, and residents of rural communities – have lower science proficiency. In 2019, students in high-poverty schools scored on average lower than mid-high-poverty, mid-low-poverty, and low-poverty schools on fourth and eighth-grade National Assessment of Educational Progress science assessment. In fourth grade, for example, students in high-poverty schools scored, on average, 33 points (22%) lower than students in low-poverty schools. The gap was 34 and 35 points in eighth and twelfth grades, respectively (NCES, 2022).

According to a report from the National Center for Educational Statistics (last updated May 2023), in fall 2021, high-poverty schools have 38 percent Hispanic students, 37 percent Black students, 30 percent American Indian and Alaskan Native students, and 23 percent Pacific Islander students, 15 percent students of Two or more races, 13 percent Asian students, and 7 percent White students (Figure 1). Students in the low-poverty (FRPL) schools are 42 percent Asian, 34 percent White, 27 percent students of Two or more races, 16 percent Pacific Islander, 12 percent American Indian/Alaskan Native, 12 percent Hispanic, and 12 percent Black. This composition of students by race and ethnicity in the high and low FRPL groups shows the complexity of disparities and demands immediate, creative, and constructive solutions.

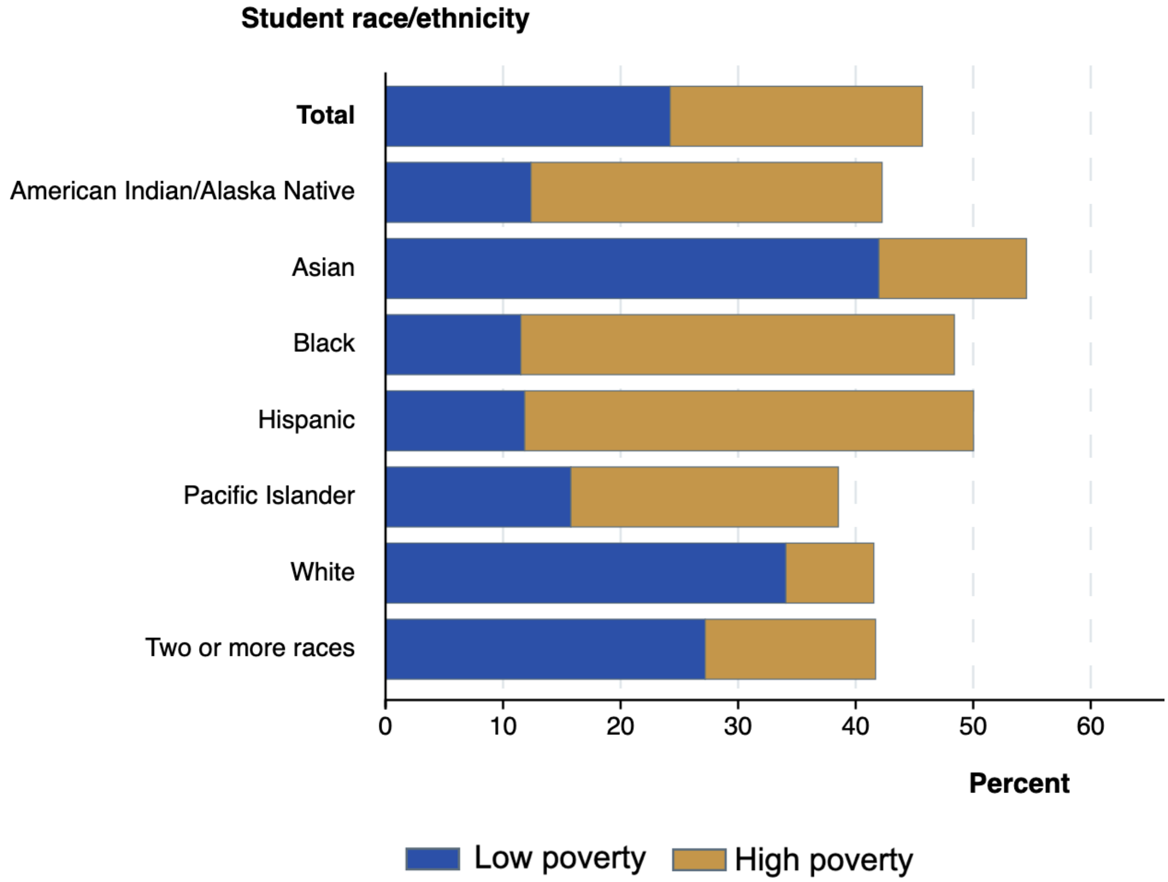

Figure 1. Race and ethnicity distribution in High and Low FRPL groups (Source: National Center for Education Statistics, 2023)

Discussion

Since the nineteen-fifties launch of Sputnik by the then Soviet Union, there has been an increased level of attention to science in the U.S. school curriculum, but no concomitant level of support for science education. The disparity in per-pupil spending between the highest quartile and lowest quartile of students eligible for FRPL is disheartening (Kumar, 2022). The median amount of money spent per pupil per school in the elementary grades decreased by 20 percent between 2000 and 2012, and while it increased by 28 percent between 2012 and 2018, the amount decreased by 10 percent when adjusted for inflation.

Beginning in childhood, socioeconomic disparity has an adverse impact on the academic outcomes of children (U.S. Government Accountability Office, 2017). Seventy years after the Brown vs Board of Education decision, new research indicates an increase in school segregation. According to Spector (2024), most of the increase in economic segregation, as measured by disparities in students eligible for FRPL took place in the last 15 years. If science education for all students remains a goal for K-12 education, efforts to address this chronic situation adversely affecting children in the elementary grades are overdue.

A troubling concern is the fact that over fifty percent of students in the highest FRPL quartile are less likely to be taught by teachers with an adequate science background. Likewise, the socioeconomic disparity is clear in the amount of money spent per pupil between students in the highest FRPL quartile and the lowest FRPL quartile in science classes. The complexity of this problem is particularly problematic in similar science classes, where technology, engineering, and mathematics disciplines are integrated alongside science, which lack adequate resources to engage all students in meaningful learning experiences (Kumar, 2022). For example, science classes integrating robotics labs would cost more in terms of materials, facilities, and teacher preparation compared to traditional labs.

Teachers spend their own money every year on school supplies. According to the U.S. Department of Education (2021), a public-school teacher spends an average $479 on classroom supplies. This generous nature of classroom teachers should not excuse school administrators from committing adequate funds to support the delivery of engaging, inquiry-based science lessons to students (Kumar, 2022).

Summary and Recommendations

Based on the disparities in science education explored in this manuscript, science for all remains an elusive goal. The existence of disparities in science education is real. Carefully planned long-term solutions would help to eliminate disparities in science education. Considering the critical importance of developmentally appropriate science experiences in K-12 grades, allocation of adequate fiscal resources in the highest FRPL quartile in our classrooms, in addition to effective policies to assure quality science learning experiences for students in low poverty, is essential.

Teachers working in high FRPL schools need access to sufficient quantities of high-quality instructional resources to deliver meaningful inquiry-based science lessons. Schools need to invest in technology tools like virtual reality and simulations. Regardless of the socioeconomic status of their students, teachers should be prepared to apply effective strategies and resources to motivate and engage students in science learning. Teachers should be equipped and ready to implement inquiry-based, minds-on pedagogies, such as counterintuitive demonstrations, problem-based learning, informal science education, etc. when allocating resources in the context of providing engaging science, school district administrators should not undervalue science classrooms in schools with high levels of poverty.

The disparity among students in the highest and lowest FRPL quartiles is alarming, especially in a country that is a leader in both democracy and economics and is well-known for significant contributions to science and technology in a variety of fields, including space exploration, research, and development, healthcare, and agriculture. The consequences of socioeconomic disparities in science classrooms can be lessened if professional science education and science teacher education organizations take the initiative to shape policies that lead to successful practices and support teachers in implementing them. This is especially important as schools and colleges work to improve diversity, equity, and inclusion. Rather than merely voicing opinions, education stakeholders—from small- to large-scale enterprises and local, state, and federal governments—must pledge to collaborate with the scientific education community to eliminate inequalities in science education.

Every student in K-12 classrooms should benefit from a quality science education in the twenty-first century. Ignoring inequalities in science education and expecting to reach science for all students is unproductive. The genesis and dynamics of disparities in education are extremely complex. However, major stakeholders of public education, such as the legislators, school board members, parents, and school administrators, should take necessary steps to ensure that students in high-FRPL classrooms receive the same high-quality science education that is available to students in low-FRPL classrooms. Science teachers should be allowed to participate in policy decisions addressing disparities in science classrooms. Eliminating the consequence of socioeconomic disparities in science classrooms will take time and commitment. However, if approached with persistence, students in high-FRPL schools can enjoy the same high-quality science education their counterparts in low-FRPL schools enjoy. Hopefully, the science education community will declare with confidence one day soon that science for all students is not an elusive goal.

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