How Families Shape STEM Achievement in the Classroom

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Abstract

This paper examines the influence of parental education on shaping children's STEM identity and achievement using Bourdieu's theory of cultural capital as a framework. Specifically, this paper explores how language development, behavioral norms, and engagement strategies that align with school and STEM-specific expectations increase students' science capital. This analysis provides a more comprehensive understanding of how opportunity gaps in science education are created and perpetuated by acknowledging the broader sociocultural structures that influence STEM readiness. Based on a literature analysis, the findings show that STEM opportunities are shaped both inside and outside the schoolhouse. At the conclusion of this paper, policy recommendations are provided as a pathway to equity, aiming to address the systems that fail to leverage students' cultural capital.

Introduction

Efforts to improve STEM outcomes in the United States have primarily focused on classroom practices, curriculum reform, or teacher quality. However, research suggests the roots of STEM achievement gaps extend beyond the school building and into the home. This paper examines the intersection of cultural capital and family involvement in shaping students' trajectories in STEM education, using Bourdieu's (1986) concept of cultural capital. The education level of a student's parents contributes to the long-term academic and STEM success of students. Bozick and Ingels noted that parental education significantly predicts not only the academic courses students take in high school, such as Algebra II and higher-level math, but also their preparedness and confidence in succeeding in them. (Bozick & Ingels, 2008).

Parental education influences STEM outcomes through cultural capital aligned with school expectations. Pierre Bourdieu's (1986) concept of cultural capital refers to the non-financial assets that promote social mobility, which institutions reward, including language use, behaviors, preferences, and forms of engagement. Capital, through interactions with a person's disposition and social contexts, produces relations of privilege or subordination within society. Archer et al. expanded the concept of cultural capital with the idea of science capital, which encompasses exposure to scientific knowledge, as well as confidence, identity, and support structures related to STEM fields. Cultural and Science capital can help explain why children from more educated households tend to outperform their peers as they enter the classroom with the capital needed to succeed. (Archer et al., 2015).

Along with their education, parental socialization practices can shape learning trajectories in ways that may impact later STEM outcomes. Wang & Degol (2017) noted that mothers talked more frequently and used more supportive speech with their daughters than with their sons. Additionally, parents devoted more time to verbal activities, mainly reading and storytelling, with girls than with boys. This variance in verbal socialization is a potential explanation for why girls consistently score higher on standardized tests of verbal ability (Wang & Degol, 2017). Parental knowledge, behaviors, and expectations can lay the groundwork for STEM achievement as socialization practices have impacts on academic performance.

Early Exposure to Science Capital

Disparities in science capital begin at an early age. While the findings of this study have been scrutinized, Hart and Risley's (2003) study on early language exposure revealed that by age three, children from professional families hear approximately 30 million more words than children from families receiving welfare assistance. This study observes 42 families for an hour each month, and based on the language observed, significant differences were found in the quality and complexity of language interactions that children experience. However, the value of the 30 million words was extrapolated and may not be generalizable, and thus might not have the impact as the article title suggests. Although it is important to note that for the 42 children observed, “86 percent to 98 percent of the words recorded in each child's vocabulary consisted of words also recorded in their parents' vocabularies”. If children are mirroring the language of their parents, then children of college-educated parents would be more likely to mimic the vocabulary and structure of college-educated speech. As this was a longitudinal study, students were tested several years after the initial assessment. Based on the findings, the amount of vocabulary used at age three was strongly associated with higher reading comprehension scores and higher level vocabulary use at ages nine or ten (Hart & Risley, 2003).

STEM fields require students to conduct language-intensive practices such as interpreting instructions, memorizing information, or articulating reasoning. The frequency and sophistication of language used at home can enable children from highly educated homes to be more proficient in the cognitive and communicative behaviors that STEM disciplines require. Archer et al. (2015) described this phenomenon as capital begetting more capital, referencing studies that found that museum visitors with higher levels of cultural capital use this capital to leverage further capital and science learning for their children (Archer et al., 2015).

Increasing science capital has positive effects on student achievement. According to Gülhan (2023), parental participation in STEM-related activities, such as museum visits, science conversations, and homework assistance, correlates with improved student performance and interest in STEM. For example, students whose parents participated in family science night activities or science museums had their interest in science learning positively affected. However, parents were three times more likely to explain science to boys than girls when using interactive science exhibits at a museum (Gülhan, 2023). Additionally, middle school children with close family members who work in a science-related field were more likely to aspire to science-related careers than those without close adults who had worked in those fields. Furthermore, students who were motivated and encouraged to study math or physics by a teacher or family member were an important predictor of a student's decision to study that field (Archer et al., 2015). Capital is increased through interactions with those who already possess capital, which affects both a student's interest in a field and their overall achievement in that field.

Cultural Capital as a Barrier to STEM Equity

A barrier to equity in STEM is the invisibility of cultural capital. Schools rarely account for the subtle ways that students from more educated families arrive already socialized into the norms of academic success. Students without this capital may be navigating school with different norms or lacking the precise academic language teachers expect, not because of cognitive deficits, but because of differences in capital. Notably, it is not the actual content or form of the capital itself, but the legitimization of capital that produces advantage or privilege within institutions. The most "legitimate" forms of capital are those whose intrinsic value is precisely converted into symbolic forms that match the requirements of the classroom. (Archer et al,2015). With this disparity in accepted cultural or science capital as students enter the classroom, to promote equity, the solution would not be to fix students but to broaden the definitions of what is accepted cultural capital.

The effects of differences in cultural capital become more pronounced when certain groups also hoard capital in their communities. Rury and Saatcioglu (2011) examined racial and ethnic segregation between suburbs and cities through the lens of opportunity hoarding. The authors argued that segregation was a process of advantage-seeking by White suburbanites, enabling them to secure the best educational opportunities for their children (Rury and Saatcioglu, 2011).

This hoarding of educational resources is also present within high schools, where privileged youth are usually disproportionately represented in advanced academic classes. This disproportionate representation provides students, who already have increased capital, with benefits that allow more access to and better performance in college. A study of a high school serving a diverse district demonstrated that the biased beliefs and actions of White parents, their children, and the teachers led to the systematic exclusion of many minority youth from advanced classes (Riegle-Crumb, King, and Irizarry, 2019).

Impacts of Cultural Capital on STEM Achievement

By not acquiring the "legitimate" cultural capital before entering the school environment, students are thus excluded from educational opportunities later in their academic journey. If capital begets capital, then a lack of the language, behaviors, or resources deemed necessary to succeed results in less capital. This is especially prevalent when studying the STEM achievement gap in universities. Black and Latinx students who began college in STEM majors are ,respectively, 19 percent and 13 percent more likely than White peers to switch to non-STEM fields. However, after accounting for social background, such as parents' education or socioeconomic status, this gap becomes statistically insignificant. This result indicates that if

Black and Latino students have the requisite science capital, they are able to persist more in STEM fields.

The rationale for creating a subset of cultural capital called science capital is that the racial gaps in persistence do not appear in non-STEM majors. Notably, Black students in the humanities are less likely than Whites to switch majors. This makes the higher switching rates among minority students unique to STEM and cannot be fully explained by background or academic preparation, as Black students are still 14 percent more likely to switch majors out of STEM than their White peers when controlling for academic preparation (Riegle-Crumb, King, and Irizarry, 2019).

Additionally, Black and Latinx students in STEM majors are 8 percent more likely to leave college without a degree compared to White students. However, unlike with major persistence, this gap remains even after controlling for social background and academic preparation, while in non-STEM fields, racial gaps in leaving university are fully explained by social background and academic preparation, especially for Latinx students. These results support the theory of opportunity hoarding as STEM fields act as gatekeeping spaces that disproportionately exclude minority students. This exclusion is not mirrored in other academic fields, suggesting that STEM is uniquely racialized. Some students may also choose to leave STEM for fields they perceive as more socially impactful. Still, such perceptions are themselves shaped by a STEM culture dominated by “legitimate” cultural capital through accepted norms and values. Such is the cost of unaddressed disparities in cultural capital or science capital. To address these gaps in the upcoming years, policy changes addressing the STEM achievement gap must consider the impact of cultural capital.

Policy Recommendations

To address the cultural dimensions of STEM inequality, schools must move beyond traditional academic reforms and tackle the invisible mechanisms that reproduce privilege through the following actions.

1. Engage families through culturally responsive STEM literacy practices by running initiatives such as bilingual math workshops, community science nights, and parent-student engineering challenges to use families' cultural values, home languages, and lived experiences to build science capital for students. Sessions should utilize the STEM Family Engagement Planning Tool to enhance the capacity of families as they support their students' STEM achievement.
2. Broaden the definition of science capital by having schools recognize that academic success involves more than vocabulary and test scores. Build lessons into the curriculum that develop curiosity, exposure, identity, and confidence, as they are valuable components of science capital (Archer et al., 2015).
3. Support early childhood STEM readiness by developing early learning programs that integrate language-rich, inquiry-based learning. Community preschools that incorporate storytelling, exploration, and hands-on activities in underresourced areas can counter early capital disparities. For example, preschools can access STEAM resources on the Head Start resource page to attain information on how to model verbal and cognitive practices that support early STEM exposure.

Conclusion

STEM achievement gaps are shaped by disparities in cultural and scientific capital that begin within the home. Parental education, language use, and community structure have an impact on how children develop their understanding of themselves as learners and future scientists. These forms of capital shape students' academic trajectories, access to opportunity, and persistence in STEM pathways. This paper has demonstrated that cultural capital, transmitted by parents who possess it, provides early advantages to students, and these early advantages compound over time. Addressing these inequities requires stakeholders to recognize the cultural foundations of academic success, expand definitions of science capital, and intentionally support families in building STEM readiness from early childhood onward. By designing systems that do not penalize those without dominant forms of capital, schools can begin to dismantle the opportunity hoarding that sustains inequity in science education and ensure all students can access it.

References

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). Science capital: A conceptual, methodological, and policy tool for making science accessible to all. Science Education, 99(5), 722–747.

Bozick, R., & Ingels, S. J. (2008). Mathematics coursetaking and achievement at the end of high school: Evidence from the Education Longitudinal Study of 2002. Education Statistics Quarterly, 10(3), 1–36.

Bourdieu, P. (1986). The forms of capital. In J. Richardson (Ed.), Handbook of theory and research for the sociology of education (pp. 241–258). Greenwood Press.

Gülhan, F. (2023). Parental involvement in STEM education: A systematic literature review. European Journal of STEM Education, 8(1), 5.

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. American Educator, 27(1), 4–9.

Pondiscio, R. (2019, June 6). Don’t dismiss that 30 million-word gap quite so fast. Education Next. https://www.educationnext.org/dont-dismiss-30-million-word-gap-quite-fast/

Riegle-Crumb, C., King, B., & Irizarry, Y. (2019). Does STEM stand out? Examining racial/ethnic gaps in persistence across postsecondary fields. Educational Researcher, 48(3), 133–144.

Rury, J. L., & Saatcioglu, A. (2011). Suburban advantage: Opportunity hoarding and secondary attainment in the postwar metropolitan North. American Journal of Education, 117(3), 307–342.

Wang, M.-T., & Degol, J. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. Educational Psychology Review, 29(1), 119–140.

Zhang, Y., Li, H., & Chen, X. (2022). A systematic review of parental involvement in STEM education. International Journal of STEM Education, 9, Article 40.