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The Impact of Social Marginalisation on Science Engagement and the Extent of Barrier Reduction

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Abstract: This paper examines the impact of social marginalisation, including race, gender, and social class, on science engagement. Socially marginalised groups, such as women, people of colour, and lower socioeconomic classes, face significant barriers in science education and careers due to discrimination, stereotyping, and limited access to science capital. The paper explores how these factors intersect to influence the formation of scientific identity and contribute to underrepresentation in scientific fields. Efforts to reduce these barriers, such as inclusive science communication and stereotype manipulation, are critically evaluated. Although these interventions offer potential solutions, they remain idealistic and face significant challenges. The paper concludes that addressing these barriers requires deep structural and cultural reforms within the scientific community.

Keywords: Social Marginalisation; Science Engagement; Science Capital; Intersectionality; Scientific Identity; Stereotypes in Science; Inclusive Science Communication; Barriers to Science Participation; Gender and Science; Race and Science; Social Class in Education.

1. Introduction

Over the past two decades, there has been a promising growth in academic figures in chemistry and biology (Dawson, 2018). However, persistent inequalities in representation continue to affect women and minorities compared to their male and non-minority counterparts (Ong, 2005). In the United States, the underrepresentation of women and minorities remains notable in higher education, particularly within the sciences (Lichtenstein et al., 2014). Data reveals that Black and Latino Americans account for less than 10 percent of doctoral degrees in the sciences, despite projections showing that these groups will constitute nearly 40 percent of the U.S. population by 2045 (Stets et al., 2017). Similarly, EU data indicate significant disparities in science education participation based on race, social class, and gender (Salvadó et al., 2021). For example, working-class families often struggle to afford science-related programs for their children due to limited incomes and occupations unrelated to science, which leads them to perceive science as irrelevant to their children's daily lives (Archer et al., 2020).

Existing research has consistently identified barriers such as discrimination, unfair treatment, stereotyping, and prejudice faced by women, minorities, and working-class groups (Belser et al., 2017; Gnilka & Novakovic, 2017). These challenges contribute to declining interest in science careers and lower engagement in science-related activities within these groups (Salvadó et al., 2021). Women of color, in particular, often report feeling perceived as different while pursuing science degrees (Mostafa, 2019). Although laboratory work or solving complex problems may temporarily help them overlook these differences, they frequently encounter both explicit and subtle challenges to their abilities and status in the scientific community (Ong, 2005). Despite these obstacles, many women of color have persisted and achieved success in the sciences (Carlone & Johnson, 2007).

However, much of the existing literature has primarily focused on specific scientific disciplines, such as physics, or has examined only the impact of two out of three critical factors—race, gender, or social class—on science engagement. Thus, this paper seeks to explore how race, gender, and social class collectively influence science engagement in socially marginalised groups. Furthermore, this study will critically evaluate approaches to reducing these barriers, contributing to the ongoing discourse on improving diversity and inclusion in science.

2. Context of Argument

Science is a crucial aspect of current societal development that influences and shapes the daily lives of society as a whole (Archer et al., 2020). The significance of engaging in science was widely acknowledged for its role in fostering national economic competitiveness, facilitating greater upward social mobility, and cultivating active citizenship (Archer & DeWitt, 2016). Recognizing the imperative for a sustained and diverse of young individuals participating, it was crucial for future societies and labor markets to promote and broaden engagement in science within post-compulsory education (Archer et al., 2017). Despite considerable human and financial investments, the recent decline in student engagement with science careers has raised international concerns about the scientific future (Murphy et al., 2019). As a result, increasing and diversifying science engagement has become a pressing concern for policymakers, practitioners, and researchers alike (DeWitt & Archer, 2015).

3. Social Marginalisation

Social marginalisation, as a global issue, has rarely been specifically defined (Messiou, 2012). Originating in the 1980s, the concept emerged as European policymakers sought a term for innovative social policies that transcended the connotations of 'poverty' and 'deprivation' (Peace & Mohammed, 2015). The term ‘social marginalisation’ was made to be less blatant, prompting thinking of the issue and moving away from the limited and disgusted notions of poverty or deprivation (Briggs, 2011). Thus, the concept of social marginalisation was initially narrowly defined as synonymous with poverty (Bhalla & Lapeyre, 1997). However, the definition of social marginalisation has encountered some controversy across different countries, resulting in slight variations in its conceptualization. The UK, for instance, initially inclined towards defining social marginalisation by emphasizing 'individuals' and 'discourses of poverty' (Burchardt et al., 1999). Whereas the early EU identified three dimensions of social marginalisation, including the economic, social, and political field (Bhalla & Lapeyre, 1997).

Social marginalisation could thus be broadly defined and was frequently employed in categorising and labelling distinct or special groups of people (Burchardt, 2000). It encompassed various levels of marginalisation, involving the lack of resources and/or deprivation of social rights (Saraceno, 2001). In discussions, it was often linked with inclusion and social exclusion (Peace & Mohammed, 2015). Thus, social exclusion and marginalisation appeared interchangeable, with their main meanings both primarily being unrecognised by others and socially isolated (Mowat, 2015). Individuals deemed 'deviants' find themselves relegated to the margins of mainstream society due to unequal power relations (Robards et al., 2020). Marginalisation manifested itself diversely in society, primarily affecting lower social classes, people of colour, women, and individuals with disabilities (Deuchar, 2009). Furthermore, social marginalisation was complex, with interconnected causes and effects that perpetuated further exclusion (Walsh et al., 2017). For example, poverty serves as both a primary cause and a significant consequence of social marginalisation.

These socially marginalised groups went through numerous struggles in their already difficult lives and attempted to alleviate the circumstances through education. Education, being a pathway to social mobility, tends to afford individuals with higher and advanced degrees greater career success and access to increased wealth (Jetten et al., 2017). However, despite schools aiming to provide a more standardised learning environment for all children, access to science education remained less widespread and uniform across society (Schinske et al., 2016). Previous research has found significant quantitative and qualitative differences in the curriculum education received by pupils living in more deprived areas of the city compared to ordinary schools, and this is particularly evident in science education (Anyon, 1998). The curriculum for these economically disadvantaged students tended to emphasise skills aligned with their low social status, focusing on practical skills needed for their future. This educational approach further exacerbated the disparity between students from poverty backgrounds and their richer peers concerning engagement in science.

While education was perceived as a means of escaping social marginalisation, it can paradoxically act as an enabler of marginalisation (Mowat, 2015). Moreover, even if marginalised groups strived to maintain a high level of participation in science, their status hindered their ability to contribute significantly to scientific exploration. In the curriculum of undergraduate physics, future physicists were framed in a narrow and enduring look through rigorous and selective narratives (Nespor, 2014). Consequently, the course marginalised almost all female students, students of colour, and those from low-income families. Such a restricted identity was both unwelcoming and unattainable for marginalised groups (Nespor, 2014).

4. Science Capital

Recently, several scholars have linked marginalisation to capital. One of them, Bourdieu, underscored that social capital served not as a mechanism for fostering general trust, but rather as a tool employed by specific social groups to uphold their exclusivity through close tied with similar groups (Li et al., 2003). Building upon Bourdieu's conceptualisation of capital, the term 'science capital' emerged to indicate the impact of social marginalisation on participation in science. In a study by Archer et al. (2015), science capital was succinctly defined as the scientific manifestation of cultural capital, encompassing behaviors, experiences, and the social capital associated with science (DeWitt et al., 2016). Capital leads families to assign different values, attitudes, expectations, and behaviours to their children that promote academic performance and science engagement (DeWitt & Archer, 2015). Notably, parental science capital assumed a mediating role in children's involvement with science (Dawson, 2018). Conversely, individuals facing social marginalisation contended with low social status and financial struggles, impeding their ability to provide sufficient resources for their children, thereby leaving them lacking a personal connection to science (Pedersen, 1996). Essentially, socially marginalised individuals lacked the capacity to aggregate the diverse economic, social, and cultural capitals associated with science to support or enhance their children's engagement or achievement in the field (Messiou, 2012).

Science capital helped to translate students' positive attitudes towards science into decisions and behaviours, with the potential to foster greater science engagement in the future (Barton & Tan, 2010). Previous research indicated that high-achieving students in science often came from richer families with robust science capital and an array of economic, social, and cultural resources sustaining their achievements (Aschbacher et al., 2010). Consequently, individuals possessing high scientific capital were more inclined to have scientific ambitions and pursue more extensive and engaged involvement in science, predominantly belonging to the comfortable middle and upper classes, with a notable dominance of males (Archer et al., 2015). DeWitt et al. (2016) discovered in their research that science literacy and family played a central role in shaping science capital. These variables could serve as predictors reflecting a child's engagement with science. Therefore, in general, lower science capital in children implies diminished science literacy, limited experience, and a lack of confidence in their skills and activities related to science (Archer et al., 2015). It was noteworthy that even when parents in a family were engaged in science-related professions, it continued to play a significant role in a child's development and the cultivation of science aspirations, in the face of the family's working-class or immigrant people of colour background (DeWitt & Archer, 2015).

5. Intersectionality and Science Identity

All the aforementioned influences on science engagement were often treated as a single factor. However, intersectionality was employed to underscore the interconnectedness of social differences, such as social class, gender, and race (Avraamidou, 2019). This concept originated from an exploration of the interplay between gender and race and was now utilised to encompass various dimensions of social discrimination and inequality (Avraamidou, 2020).

Previous research has employed an intersectional approach to investigate how the convergence of race and gender influences science engagement, revealing that race and gender created a dual challenge (Cross et al., 2017). Brickhouse et al. (2000) investigated the influences and responses of working-class 7th-grade young women of colour in school science. One of them, Crystal, an African American girl who was the only minority girl in her class, faced extreme forms of evaluation from teachers and an inability to fit in with her classmates. She felt threatening prejudice from white boys at all times, which was detrimental to her ability to increase her engagement in science class. It is noteworthy that Crystal encountered other minority girls when she later transferred to a different school. However, this did not alleviate Crystal's marginalisation, instead their group of girls of colour needed to be quiet and well-disciplined in the classroom in an attempt to briefly fit in with the classroom and other peers. This excluded group adhered to rules and then gained acceptance may perpetuate the ongoing plight of the marginalised group (Mowat, 2015).

For socially marginalised students, the disparities in science participation resulting from intersectionality was also evident at the school level. In the United States, the substantial increase in income inequality for marginalised populations has led to the children of these impoverished minorities attending under-resourced schools (Ferri & Connor, 2014). These schools shared notable similarities, including deteriorating facilities, overcrowded classrooms, and severe shortages in the number of teachers and science equipment (Darling-Hammond, 2015). Rothstein (2004) argued that the inequalities arising from the intersectionality of social stratification and race were so strong that schools alone were insufficient to overcome these disparities. However, there were variations in the impact of the intersectionality of social marginalization. According to a study by Strand (2014) on 16-year-old British adolescents, it was observed that Caribbean boys of low socio-economic status were significantly disengaged from education, followed by white working-class British boys. This discrepancy was attributed to differences in the educational aspirations of the parents of these adolescents for their children, as well as the aspirations of the adolescents themselves (Strand, 2014). Nonetheless, it was crucial to affirm that the intersectionality of social marginalisation obviously underscored inequalities in educational and scientific engagement.

Therefore, intersectional approaches acknowledged the diversity and ambivalence of identities, and the resultant inequalities exacerbated the implications for science engagement, contributing to the formation of a scientific identity (Canfield et al., 2020). Thus, a scientific identity can be a reflection of one's view of oneself, as well as the extent to which others recognise one as a man of science (DeWitt et al., 2016). This self-perception and its recognition affect students' engagement with science and indirectly influences their consideration of whether science is a suitable path for them in their future career choices (Archer & DeWitt, 2016). Research has consistently affirmed the central role of scientific identity in the desire to pursue a scientific field or become a scientist, repeatedly identifying it as a crucial factor in minority students' participation in scientific research (Stets et al., 2017).

Furthermore, ideals about the identity of a scientist can allow students in schools to shape their scientific identity more strongly, but this can be quite difficult for socially marginalised groups (Brickhouse et al., 2001). According to Social Identity Theory, denoted that a person's sense of self is highly dependent on their social background and the group they belong to (Rushton & Reiss, 2021). Thus, individuals can think about themselves and shape their behaviour based on their membership in a social group (Azevedo & Mann, 2022). The identities exhibited by students in school can reflect the social class of their parents, thus allowing the construction of scientific identity to manifest unequal social relations within the school context (Brickhouse & Potter, 2001).

This notion was supported by Jetten et al. (2017), who affirmed that students of low socioeconomic status, particularly individuals of colour, and their social backgrounds and associated identities were insufficient to support their engagement in and future pursuit of science-related fields in the school. Avraamidou's (2020) study further validated this situation, highlighting that white students were acknowledged by their teachers merely for copying and memorising facts, promoting passive and non-creative engagement in science. Conversely, non-heritage American girls in the study remained excluded from the scientific domain despite actively participating in science experiments, solely because they failed to conform to a specific identity deemed as scientific. These marginalised realities were exposed through intersectionality studies and the absence of a scientific identity, perpetuating the belief that poverty, sexism, and racism seem to become inevitable and expected in scientific engagement (Avraamidou, 2020).

6. Stereotype: Masculinity

Current research indicates that many individuals harbor stereotypical or limited perceptions of scientists from early childhood (Losh et al., 2008). Salvadó et al. (2021) underscored that while these views may not inherently be extremely negative, they carried marginalizing connotations that can hinder socially marginalised individuals from actively participating in science and realizing their scientific aspirations.

Archer et al. (2020) conducted five surveys targeting 10-18 year-olds, revealing that students' identification with and aspirations for science are influenced by the confluence of science and masculinity. This finding aligned with the established pattern illustrated by Moreau et al. (2010) through focus group data. Qualitative data collected in the Archer et al. (2020) study further highlighted young girls consistently expressing the perception of a strong association between masculinity and science in the male image. They noted that their teachers tended to limit discussions of scientists to males and were hesitant to mention female scientists. These insights underscore the potential for girls to develop a negative association between themselves and their scientific identity, leading to decreased engagement with science.

Moreover, additional research indicated that physics, among scientific disciplines, exhibited the strongest association with masculinity (Francis et al., 2017). Therefore, masculinisation of physics can challenge many young women's constructs of femininity (Cheryan et al., 2011). Ong's (2005) findings suggested that women pursuing studies in physics often conceal their femininity, altering aspects such as their dress and speech. This has evolved into a stereotype within the scientific community, describing these female physicists as less feminine than their non-scientific peers (Eardley, 2021). This stereotype was further validated by the self-perception of these female physicists, who as revealed by Carli et al. (2016) considered themselves less 'girly' than their counterparts. While these attempts to conceal their true appearance may reflect ambivalence toward the existing identity of scientists, this contradictive status quo reinforces the association between science and the image of masculinity, serving as a barrier for individuals, particularly girls, to pursue and engage in science (Mitchell & McKinnon, 2019).

Additionally, the stereotype of scientists was not limited to masculinity but extended to race. Whites, especially White males, were often perceived as representing a neutral and objective view of science, as they were seen as individuals rather than representatives of their race (Ong, 2005). Facing the prevailing image of scientists as white males, women of colour were discouraged from furthering their exploration in the field of physics (Margolis & Fisher, 2002). Consequently, these minority female physicists adeptly navigated gender boundaries but faced increased challenges (Mostafa, 2019). The risk was high that the masculine image they hold may render them perceived as unnatural and non-conforming, potentially leading women to withdraw from the scientific field due to this nervous relationship (Seymour & Hewitt, 1997; Valian, 1999). Thus, the underrepresentation of women and minority females in science served as additional evidence supporting the dominance of males in the field (Francis et al., 2017).

7. Stereotype: Intelligence

Furthermore, according to the assertions of DeWitt et al. (2013), the image of a scientist was linked to attributes that may be perceived as possessed by only a few, such as intelligence. This association can foster the belief that these attributes or scientific skills were innate and not acquired. Although the majority of students, at the age of 10, may not initially believe that science learning and exploration require intelligence, the idea that a connection existed between science and cleverness develops and solidifies as they received systematic education (Archer et al., 2020). Students, as indicated by Moreau et al. (2010), tend to believed that scientists were inherently smart or talented. For instance, an 11-year-old black girl from the lower middle class mentioned that a common reason why students did not pursue science was the perception that science was exceptionally challenging. This perspective was supported by other studies, especially among young women who often felt they lacked the intelligence to continue in science, particularly in physics (Scholes & Stahl, 2022).

This self-imposed harsh judgment came from experiences of injustice in science and was a status quo that lacked substantial support from relevant research. Mostafa (2019) noted that young males and females performed equally well in science, and even young females tended to excel in reading. Mostafa's research also reveals that young males exhibited significantly more interest and confidence in science than their female counterparts. Thus, the notion of being intelligent was not solely reflected in academic achievement but was entangled in deeper social marginalisation (Napp & Breda, 2022). This alignment also implied that intelligence was associated with being intelligent, upper-middle class, white, and masculine. Students possessing these characteristics tended to increase their participation in science regardless of their academic achievements, while working-class, female, and ethnic minority students may drift away from science because they perceive themselves as not 'intelligent' enough (Schinske et al., 2016).

8. Inclusive Science Communication

In this section, I will discuss the potential of inclusive science communication to reduce barriers. Referring to the impact of social marginalisation on science engagement mentioned above, if the current status quo was maintained, it fostered and exacerbated racism, classism, and sexism (Canfield et al., 2020). These oppressive behaviors only benefited specific audiences, such as upper-middle-class whites. Therefore, a fundamental principle of an equity-oriented approach to science education was that science teachers needed to take on the significant responsibility of fostering a culture of science in their students (Tan & Barton, 2010). Cultural integration stood out among these principles as the core of equitable science, addressing the complex challenges that many marginalised young people face in bridging the gap between the 'cultural world of the home' and the 'world of school science' (Lee & Fradd, 1998, p. 14).

The study by Tan & Barton (2010) investigated how these challenges were mitigated by experiential, inclusive education. They explored a school situated in a poverty community in the northeastern United States, predominantly serving ethnic minorities and lower social classes. The focus of the investigation was the 6th-grade science classroom of a white male teacher, Mr. M. In the formal classroom setting, Mr. M employed whole-class demonstrations, discussions, and activities to ensure a participatory environment. In the informal classroom, he organised field trips and urban science activities to establish a connection between the students and science, allowing them to develop a subtle identification with science. Simultaneously, such activities involved both students and parents, promoting the transmission of attitudes and values related to science. Students gradually developed a positive identity during these activities, encouraging them to share perspectives in an inclusive learning process. This study underscored the crucial role of science teachers in education and demonstrates that children from minority and low-income families can develop an interest in science with appropriate support, facilitating future decisions to participate in science through inclusive science communication.

A study conducted by Salvadó et al. (2021) revealed similar results. They designed and implemented science workshops for 86 children vulnerable to social marginalisation, all belonging to low-income communities and minority groups historically excluded from such learning opportunities due to marginalisation. The study's results confirmed the positive impact of the science workshops in enhancing some aspects of science capital and cultivating a more inclusive science identity, consequently fostering increased interest in science education and engagement among these girls and minorities.

However, these promising studies only created an ideal environment. Research indicated that both school and home environments play critical roles (Xu & Filler, 2008). Specific elements of science capital, such as parental understanding of the utility of science qualifications, were more likely to receive interventions compared to other elements, like involving family members in science-related work (Salehjee, 2022). The current systems were not ideal for supporting science capital (Archer et al., 2015). For instance, science museums and zoos had the potential to enhance the development of science capital in their visitors. Visitors can access information about various ways of engaging with science and experience the practical and aesthetic aspects of science. However, these well-designed galleries may be too expensive for working-class children due to entrance fees and their location in urban centers. Consequently, visitor statistics for these spaces may still favor those with more scientific and cultural capital (Nespor, 2014). Salvadó et al. (2021) also noted in the study that scientific workshops had historically been limited to middle and upper-income communities due to their high cost.

At the societal level, inclusive science communication can be viewed as a component of improved policy and increased participation, but it has also faced criticism for imparting a capitalist character to science (Dawson, 2018). Thus, when these scientific interventions that would have uplifted the status of marginalised groups were once again confronted with the issue of being perceived as 'privileged', what needed to be realised was that the current experience of science remained inches away from compulsory education (Mostafa, 2019). Moreover, these interventions should emphasize the relevance of science to students' lives. The underlying principle of this intervention was to make students realise that science was pertinent to their current and future lives (Aschbacher et al., 2010). Consequently, they will be more inclined to continue pursuing science even after it is not mandatory. However, socially marginalised students often face home environments lacking resources, with parents engaged in manual labor and unable to establish the relevance of science to their children's lives (Barton & Tan, 2010). All these challenges signified that the barriers posed by social marginalisation cannot be fully mitigated by idealised interventions.

9. Stereotype Manipulation and Being Outstanding

In addition to inclusive science communication, stereotype manipulation can contribute to alleviating barriers. The discussion above has highlighted the stereotype of the scientist associated with a masculine image and intelligence. Consequently, this stereotypical image of the scientist can be reimagined to encourage science engagement. In Ong's (2005) study, Kendra overtly rejected conforming to the conventional appearance of a physicist and, over two years, utilised her race and gender as resources both in the classroom and privately. She increasingly presented herself as a 'loud black girl,' using this image as a form of resistance. This recognisable stereotype gradually allowed colleagues to understand Kendra culturally, and her character traits earned her credibility in the scientific community.

Kendra's experience demonstrated her breaking prevailing attitudes and discriminatory cultural norms towards black individuals by 'performing' and ultimately facilitating further scientific research. She embraced self-confidence by choosing to 'value certain aspects of African American women' in the face of discrimination resulting from intersectionality. This creative approach enabled her to embody the appearance of a woman of colour while reconciling the conflicting aspects of her educational, gender, and racial identities (Ong, 2005). This allowed her to utilize these qualities to navigate and excel in challenging environments, achieving both mediocrity and greatness in the field of science. However, it is important to acknowledge that Kendra's actions also contribute to reinforcing stereotypes about black girls (Salvadó et al., 2021). For many individuals facing multiple forms of discrimination, the cost of reinventing a new image was substantial (Taylor, 2018). Many people choose to remain silent due to the potential consequences they cannot afford (Brickhouse et al., 2000).

In addition, being outstanding at one's job can also help overcome discrimination (Ong, 2005). Amy, the only female, and minority in her class, received respectful treatment from her classmates both in and out of class. However, after a mid-term exam where she earned the only A* in the class, her classmates enthusiastically invited her to join after-school study groups and other gatherings for physics majors. For Amy, her confidence was closely tied to her abilities and performance as a top student. She earned equal respect by demonstrating her excellence, a phenomenon also supported by Pearson's (2005) findings. Excelling in public and gaining recognition for good work can challenge preconceived stereotypes about people of color and their scientific abilities. Additionally, Pearson (2005) conducted a study of black Ph.D. chemists about their careers as well, and the respondents indicated that their outstanding undergraduate as well as postgraduate graduate grades and other academic accomplishments overcame the discrimination and allowed them to be more scientifically engaged in a predominantly White university.

However, these respondents also indicated that achieving outstanding undergraduate and graduate grades in the sciences is not an easy task for African Americans. This was because these interviewees tended to attend predominantly Black traditional universities for their undergraduate degrees, which often faced shortages of equipment and facilities in laboratories due to funding constraints. Additionally, there was insufficient faculty to teach critical reading and analysis of scientific readings, skills that were not adequately covered in their previous education (Pearson, 2005). As a result, they faced stiff competition from white peers at research universities.

Moreover, pursuing mediocrity in science was challenging for these minority women (Ceci et al., 2014). Nor should we conclude, in the face of Amy's and black Ph.D.'s success, that women and minority groups needed to manipulate stereotypes or strive for exceptionalism to gain more recognition and participation in science (Hill et al., 2016). Therefore, while the aforementioned pathways can alleviate the barriers brought about by social marginalisation in an ideal state, they still encounter many challenges and difficulties to a large extent. What the scientific community needs are more far-reaching structural and cultural reforms that fundamentally change the system, interaction-wise (Azevedo & Mann, 2022).

10. Conclusion

In summary, research on the impact of social marginalisation on science engagement highlighted the intricate interplay between social class, ethnicity, and gender-related factors that diminish science engagement. Science capital emphasised the values and behaviors that families instill in their children, making it challenging for children from working-class families to access science capital and hindering their pursuit of science engagement. Race, gender, and social class further compounded the barriers faced by marginalised groups, as intersectionality underscored the difficulty of establishing a scientific identity consistent with science engagement. Additionally, stereotypes of science that emphasised masculinity and intelligence deter these marginalised groups from pursuing science engagement. Women studying in the sciences often concealed their femininity, reinforcing existing stereotypes.

Nevertheless, efforts to reduce these barriers include inclusive science communication, and providing minority children from lower social classes with opportunities to enhance their engagement in science through experiential science classrooms. However, this initiative was overly idealistic, and achieving science engagement through inclusive education remained challenging beyond compulsory education. Moreover, manipulating stereotypes and striving for excellence can mitigate the preconceived notion that marginalised individuals are incapable of participating in science, but this comes at a substantial cost and requires extraordinary effort. It should not be the case that women and minority groups must conform to reimagined standards or excel to gain more engagement in science. Thus, both approaches can only partially reduce the barriers posed by social marginalisation to a large extent.

References

[1] Anyon, J. (1998). The social context of educational reform. A light in dark times: Maxine Greene and the unfinished conversation, 219-228.

[2] Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). “Science capital”: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. Journal of research in science teaching, 52(7), 922-948.

[3] Archer, L., & DeWitt, J. (2016). Understanding Young People's Science Aspirations: How students form ideas about ‘becoming a scientist’. Taylor & Francis.

[4] Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to ‘Triple Science’at KS4 in England. Research Papers in Education, 32(3), 296-315.

[5] Archer, L., Moote, J., Macleod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10–19.

[6] Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspirations in science, engineering, and medicine. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 47(5), 564-582.

[7] Avraamidou, L. (2019). Stories we live, identities we build: How are elementary teachers’ science identities shaped by their lived experiences? Cultural Studies of Science Education, 14(1), 33-59.

[8] Avraamidou, L. (2020). Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectionality lens. Cultural Studies of Science Education, 15(2), 323-345.

[9] Azevedo, F. S., & Mann, M. J. (2022). An investigation of students’ identity work and science learning at the classroom margins. Cognition and Instruction, 40(2), 179-205.

[10] Barton, A. C., & Tan, E. (2010). We be burnin'! Agency, identity, and science learning. The Journal of the Learning Sciences, 19(2), 187-229.

[11] Belser, C. T., Prescod, D. J., Daire, A. P., Dagley, M. A., & Young, C. Y. (2017). Predicting undergraduate student retention in STEM majors based on career development factors. The Career Development Quarterly, 65(1), 88-93.

[12] Bhalla, A., & Lapeyre, F. (1997). Social exclusion: towards an analytical and operational framework. Development and change, 28(3), 413-433.

[13] Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 37(5), 441-458.

[14] Brickhouse, N. W., & Potter, J. T. (2001). Young women's scientific identity formation in an urban context. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 38(8), 965-980.

[15] Briggs, D. (2011). New avenues to school exclusion and social exclusion for Urban young people in the UK. In The well-being, peer cultures and rights of children (pp. 133-157). Emerald Group Publishing Limited.

[16] Burchardt, T. (2000). Social exclusion: concepts and evidence. In Breadline Europe (pp. 385-406). Policy press.

[17] Burchardt, T., Le Grand, J., & Piachaud, D. (1999). Social exclusion in Britain 1991-1995. Social policy & administration, 33(3), 227-244.

[18] Canfield, K. N., Menezes, S., Matsuda, S. B., Moore, A., Mosley Austin, A. N., Dewsbury, B. M., Feliú-Mójer, M. I., McDuffie, K. W., Moore, K., & Reich, C. A. (2020). Science communication demands a critical approach that centers inclusion, equity, and intersectionality. Frontiers in Communication, 5, 2.

[19] Carli, L. L., Alawa, L., Lee, Y., Zhao, B., & Kim, E. (2016). Stereotypes about gender and science: Women≠ scientists. Psychology of Women Quarterly, 40(2), 244-260.

[20] Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 44(8), 1187-1218.

[21] Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. Psychological science in the public interest, 15(3), 75-141.

[22] Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women’s anticipated success in STEM? Social psychological and personality science, 2(6), 656-664.

[23] Cross, K. J., Clancy, K. B., Mendenhall, R., Imoukhuede, P., & Amos, J. R. (2017). The double bind of race and gender: A look into the experiences of women of color in engineering. Proceedings–American Society of Engineering Education Annual Conference & Exposition (ASEE), Columbus, OH. June 24-28, 2017,

[24] Darling-Hammond, L. (2015). The flat world and education: How America's commitment to equity will determine our future. Teachers College Press.

[25] Dawson, E. (2018). Reimagining publics and (non) participation: Exploring exclusion from science communication through the experiences of low-income, minority ethnic groups. Public understanding of science, 27(7), 772-786.

[26] Deuchar, R. (2009). Gangs, Marginalised Youth and Social Capital. ERIC.

[27] DeWitt, J., & Archer, L. (2015). Who aspires to a science career? A comparison of survey responses from primary and secondary school students. International Journal of Science Education, 37(13), 2170-2192.

[28] DeWitt, J., Archer, L., & Mau, A. (2016). Dimensions of science capital: exploring its potential for understanding students’ science participation. International Journal of Science Education, 38(16), 2431-2449.

[29] DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, brainy and normal: Children's and parents' constructions of those who are highly engaged with science. Research in Science Education, 43, 1455-1476.

[30] Eardley, D. D. (2021). Repressed Femininity Among Women Scientists in Academia Pacifica Graduate Institute].

[31] Ferri, B. A., & Connor, D. J. (2014). Talking (and not talking) about race, social class and dis/ability: Working margin to margin. Race Ethnicity and Education, 17(4), 471-493.

[32] Francis, B., Archer, L., Moote, J., DeWitt, J., MacLeod, E., & Yeomans, L. (2017). The construction of physics as a quintessentially masculine subject: Young people's perceptions of gender issues in access to physics. Sex Roles, 76, 156-174.

[33] Gnilka, P. B., & Novakovic, A. (2017). Gender differences in STEM students' perfectionism, career search self-efficacy, and perception of career barriers. Journal of Counseling & Development, 95(1), 56-66.

[34] Hill, C., Miller, K., Benson, K., & Handley, G. (2016). Barriers and Bias: The Status of Women in Leadership. American Association of University Women.

[35] Jetten, J., Iyer, A., & Zhang, A. (2017). The educational experience of students from low socio-economic status background. Self and social identity in educational contexts, 112-125.

[36] Lee, O., & Fradd, S. H. (1998). Science for all, including students from non-English-language backgrounds. Educational researcher, 27(4), 12-21.

[37] Li, Y., Savage, M., & Pickles, A. (2003). Social capital and social exclusion in England and Wales (1972–1999). The British journal of sociology, 54(4), 497-526.

[38] Lichtenstein, G., Chen, H. L., Smith, K. A., & Maldonado, T. A. (2014). Retention and persistence of women and minorities along the engineering pathway in the United States. Cambridge handbook of engineering education research, 311-334.

[39] Losh, S. C., Wilke, R., & Pop, M. (2008). Some methodological issues with "Draw a Scientist Tests" among young children. International Journal of Science Education, 30(6), 773-792.

[40] Margolis, J., & Fisher, A. (2002). Unlocking the clubhouse: Women in computing. MIT press.

[41] Messiou, K. (2012). Collaborating with children in exploring marginalisation: An approach to inclusive education. International Journal of Inclusive Education, 16(12), 1311-1322.

[42] Mitchell, M., & McKinnon, M. (2019). 'Human'or 'objective'faces of science? Gender stereotypes and the representation of scientists in the media. Public understanding of science, 28(2), 177-190.

[43] Moreau, M. P., Mendick, H., & Epstein, D. (2010). Constructions of mathematicians in popular culture and learners' narratives: a study of mathematical and non-mathematical subjectivities. Cambridge Journal of Education, 40(1), 25-38.

[44] Mostafa, T. (2019). Why don't more girls choose to pursue a science career?

[45] Mowat, J. G. (2015). Towards a new conceptualisation of marginalisation. European Educational Research Journal, 14(5), 454-476.

[46] Murphy, S., MacDonald, A., Wang, C. A., & Danaia, L. (2019). Towards an understanding of STEM engagement: A review of the literature on motivation and academic emotions. Canadian Journal of Science, Mathematics and Technology Education, 19, 304-320.

[47] Napp, C., & Breda, T. (2022). The stereotype that girls lack talent: A worldwide investigation. Science advances, 8(10), eabm3689.

[48] Nespor, J. (2014). Knowledge in motion: Space, time and curriculum in undergraduate physics and management. Routledge.

[49] Ong, M. (2005). Body projects of young women of color in physics: Intersections of gender, race, and science. Social problems, 52(4), 593-617.

[50] Peace, R., & Mohammed, M. M. (2015). Social exclusion: A concept in need of definition. Omran For social sciences, 4(14), 123-138.

[51] Pearson, W. (2005). Beyond small numbers: Voices of african american phd chemists. (No Title).

[52] Pedersen, W. (1996). Working-class boys at the margins: Ethnic prejudice, cultural capital, and gender. Acta sociologica, 39(3), 257-279.

[53] Robards, F., Kang, M., Luscombe, G., Hawke, C., Sanci, L., Steinbeck, K., Zwi, K., Towns, S., & Usherwood, T. (2020). Intersectionality: Social marginalisation and self-reported health status in young people. International journal of environmental research and public health, 17(21), 8104.

[54] Rothstein, R. (2004). Class and schools: Using social, economic, and educational reform to close the Black–White achievement gap.

[55] Rushton, E. A., & Reiss, M. J. (2021). Middle and high school science teacher identity considered through the lens of the social identity approach: a systematic review of the literature. Studies in science education, 57(2), 141-203.

[56] Salehjee, S. (2022). Inclusion and equity in science education. In Debates in Science Education (pp. 169-187). Routledge.

[57] Salvadó, Z., Garcia-Yeste, C., Gairal-Casado, R., & Novo, M. (2021). Scientific workshop program to improve science identity, science capital and educational aspirations of children at risk of social exclusion. Children and Youth Services Review, 129, 106189.

[58] Saraceno, C. (2001). Social exclusion: Cultural roots and diversities of a popular concept. conference "Social exclusion and children", at the Institute for Child and Family Policy, Columbia University, New York,

[59] Schinske, J. N., Perkins, H., Snyder, A., & Wyer, M. (2016). Scientist spotlight homework assignments shift students' stereotypes of scientists and enhance science identity in a diverse introductory science class. CBE—Life Sciences Education, 15(3), ar47.

[60] Scholes, L., & Stahl, G. (2022). 'I'm good at science but I don't want to be a scientist': Australian primary school student stereotypes of science and scientists. International Journal of Inclusive Education, 26(9), 927-942.

[61] Seymour, E., & Hewitt, N. M. (1997). Talking about leaving (Vol. 34). Westview Press, Boulder, CO.

[62] Stets, J. E., Brenner, P. S., Burke, P. J., & Serpe, R. T. (2017). The science identity and entering a science occupation. Social Science Research, 64, 1-14.

[63] Strand, S. (2014). Ethnicity, gender, social class and achievement gaps at age 16: intersectionality and 'getting it'for the white working class. Research Papers in Education, 29(2), 131-171.

[64] Tan, E., & Barton, A. C. (2010). Transforming science learning and student participation in sixth grade science: A case study of a low-income, urban, racial minority classroom. Equity & Excellence in Education, 43(1), 38-55.

[65] Walsh, K., Scharf, T., & Keating, N. (2017). Social exclusion of older persons: A scoping review and conceptual framework. European Journal of ageing, 14, 81-98.

[66] Xu, Y., & Filler, J. (2008). Facilitating family involvement and support for inclusive education. School Community Journal, 18(2), 53.