The not-so-humble origins of the American professoriate

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Introduction

Students of science policy have focused on a number of factors that shape the life chances of those who would be STEM scientists. Early research focused on the functions that educational prestige, scholarly productivity, and sponsorship played in transitions to successful academic careers. An important body of work has demonstrated that these processes do not always operate in a universal way; for example, meritocratic norms are strained in the case where women, members of underrepresented racial and ethnic groups, and the foreign born are less likely to acquire, maintain, and progress in academic scientific careers.[1] Nevertheless, over the years women and the foreign born have made substantial progress in representation and closing achievement gaps. By contrast, participation by members of underrepresented racial and ethnic minority groups remains profoundly low, and progress is slight. This is despite decades of focused policy attempts to increase representation. I begin with what we know about the gender, foreign-born and racial/ethnic pattern of federal science training. I then argue that socioeconomic status of the family of origin—a critically important construct for status attainment research—is largely absent from theoretical or empirical studies of science policy. I use several data sources to demonstrate that failure to account for socioeconomic status results in policy designs that will have limited success in increasing either equity or diversification in the scientific labor force. I conclude with research questions that may shed light on the consequences of socioeconomic origin for the scientific workforce.

Federal graduate training policies

For the higher education system (compared to elementary and secondary levels), the federal government assumes substantial responsibility for financing the educational endeavor. First, the federal government provides crucial support for the nation's basic research enterprise, much of which runs through its public and private universities, and which results in research and teaching assistantship funding to graduate students. I argue that this part of the system is the first-tier system. Second, the federal government funds hundreds of programs that provide fellowship and traineeship opportunities for students, particularly in STEM fields.[2] Finally, the federal government directly subsidizes student loans to students to pay tuition, an American debt burden second only to mortgages.[3] These last two mechanisms constitute the second-tier part of the training system. The first-tier system advantages men and Asians, the second-tier system disproportionately benefits women and members of domestic minority groups.

To elaborate, the US federal government is the single biggest funder of graduate education in science and engineering.[4] In 2011, it funded the majority of research assistantships (51%) and traineeships (61%), and one quarter (24%) of fellowships. The research assistantship is by far the most common federal mechanism of support—73% of federally supported graduate students are funded through a research assistantship—and the majority of these are at research extensive doctoral universities. Despite the central role of the federal government in such training, it is only recently that there have been recommendations to evaluate how it works.[5]

It is important to emphasize that research assistantships—which constitute the lion's share of doctoral research training, and are the backbone of the first-tier system—do not fall within the purview of federal training programs or their evaluation.[1] For example, NIH funded more than six times as many research assistantships as traineeships in 2008, and it is only recently that a strategic plan from one if the NIH Institutes calls for evaluating them.[6] By contrast, the Office of Science and Technology Policy recently undertook a review—at the behest of Congress--of the federal compensatory STEM training programs. It identified a plethora of programs—226 programs administered by 14 federal agencies, the majority of which have been formally evaluated.[1] While traineeships have substantial planning and reporting requirements related to attraction, retention and promotion of diverse populations of students, research assistantships do not. The part of the system devoted to diversification (formal training programs) has shown some modest results, while the part of the system devoted to the majority of the actual training work (research assistantships) has not.

Finally, the federal government's role in subsidized loan support for the "self-support" category is noteworthy. Loans are taken out to make up for shortfalls in support from funded research and formal training programs: In an equitable system, one would expect loan burdens to be independent of gender, race, or ethnicity. In short, graduate education, whether directly or indirectly, is subsidized by the federal government, making the federal government the financial engine that drives STEM graduate training.

Given the relative importance of federal funding to STEM graduate training, it is noteworthy that the stratification that occurs at the undergraduate level persists in all three types of graduate support. Men and women, domestic and foreign born, and Whites and members of minority groups are supported in graduate training in systematically different ways. Men (31%) are more likely to be supported by research assistantships than women (22%). Men are less likely to support themselves (12% for men, 18% for women), and women take on higher levels of graduate student debt. Members of domestic minority groups also take on more graduate debt than do Whites.[7] Women (29%) are somewhat more likely to be supported by fellowships or traineeships than men (24%), but these are much smaller categories of support relative to the research assistantship, and the traineeships are part of the second tier system. Domestic Whites (28%) and Asians (32%) are more likely to be supported by research assistantships, as are foreign-born students on temporary visas, fully half of whom are supported by a research assistantship.[8] These differences persist even when field composition (which varies by gender, race, ethnicity, and foreign-born status) is taken into account.[9] Fellowships and traineeships support 35% of members of under-represented minority groups; unlike research assistantships, these federally supported compensatory programs require diversity plans and accountability from the universities they fund.

Extant federal data support my assertion that there is a two-tiered system of federal support for graduate training that stratifies by gender, race and ethnicity. The first-tier STEM education system operates through research project grants to principal investigators and their universities, and systematically advantages White, Asian, and foreign-born males at the best resourced institutions. To counteract this dynamic, the federal government encouraged the development of a compensatory secondary training system since 1972 that advantages women and members of domestic racial and ethnic groups. Indeed, policy reviews credit such efforts with increasing the supply, if not the deployment, of doctoral-trained racial and ethnic minorities.[10] In the first-tier system, there are few ways to track its accountability: Principal investigators have a wide degree of discretion about which students to hire, how they will be educated and supervised, and the conditions under which they work. Policy documents do not refer to this as a training system at all: Apart from its sheer volume, very little is known about how it operates (except that it trains the majority of PhD-level scientists in the United States). The traditional first-tier system is in sharp contrast to the compensatory second-tier training system, which was developed by the federal government over forty years to foster gender, racial and ethnic diversity in the STEM fields. In the case of gender, substantial progress has been made; however, with respect to under-represented ethnic and racial minority groups, progress is slow. I argue here and elsewhere[10] that the construct of socioeconomic status is largely missing from science policy debates.

The missing construct: Class

What has been missing from science policy discussions is the role that socioeconomic status plays in perpetuating disparities of access to scientific careers. A major contribution of the Obama Administration has been to re-introduce the concept of class into American political discourse, particularly the discourse related to higher education. The role of class in education is crucial on many levels, and generates numerous tough political questions given the nation's ostensible commitment to equal opportunity. One of the enduring themes of US science policy is that it seeks to import (through immigration policy) and cultivate (through higher education) the "best and brightest." The concept of the "best and brightest" is shorthand for norms of meritocracy; this ideology hides the role of social, economic and political factors that produce such individuals. Just who are the "best and brightest," and if they are so great, how can American policy make or import more of them? Most important, with what consequences does the United States pursue such a strategy?

An empirical inquiry into the class origins of the American professoriate

In this section, I focus empirical attention on one ideal-type of the "best and brightest:" the American professoriate. A person who has an earned PhD in the sciences, and who works in a full-time tenured or tenure track position, has reached the highest level of educational attainment possible in society. Such a person has experienced an intense series of selection processes oriented to identifying and cultivating merit. Of course, there is variability among such professors (since by definition, not everyone can be the "best and brightest" within the class of professors). My point here is that relative to all other classes of employment in the American economy, the class of full-time tenured and tenure-track professors is arguably among a small handful of the employment categories constituted by the so-called "best and brightest" American employees.

In particular, I seek to highlight the class origins of American professors. Empirical attention to the politically inert concept of class in STEM careers may help to focus SciSIP research on macro-level policy factors that persist in limiting diversification of the STEM professoriate.

Higher education funding is increasingly federal at the same time that state and local education expenditures decrease and their academic policies become sillier. How does this disconnect affect the recruitment and maintenance of a diverse STEM professoriate? Local financing (and politics) of schools means that many American children are deprived of quality science education—both practically and theoretically (i.e., lacking key scientific concepts). This set of policies affect poor children disproportionately, and children from underrepresented racial and ethnic groups are disproportionately poor.[11] The essay is intended to bring attention to the intersections of race and class, how those intersections are ignored by mainstream higher education policy, and how explicit attention to the intersections will improve understanding about persistent challenges to diversifying the scientific labor force.

I rely on a variety of data sources, including from the US Census Bureau, the US Department of Education, the National Science Foundation, and original data collected by colleagues and me to present the demographic picture.[12] In Table 1[13], I present the formal educational attainment of various subpopulations of the American population: Adults over 25 (by men and women),[14] parents (by fathers and mothers),[15] parents of tenured and tenure track professors (by fathers and mothers),[16] and parents of NIH-funded doctoral trainees (by fathers and mothers).[17] The bottom row of the table shows the average for each group based on a six point scale; the main body of the table shows the distribution across educational categories. In the general population, adult men and adult women are equally well educated; mothers of children who are currently under 18 are slightly better educated than fathers of such children, but note the small magnitude of the difference. By contrast, fathers of professors are much better educated than the mothers of professors (t-test of mean difference critical value=8.5); furthermore, there is an even greater difference in the educational levels of the fathers of NIH trainees compared to the mothers of NIH trainees (t-test of mean difference critical value =4.53). Of course, the mothers of NIH trainees are much better educated than both men and women in the general populace, other mothers, and even of fathers of professors. In a country where all indications are that gender differences in education are converging, or even beginning to favor women, we continue to observe marital hypergamy among mothers who raise scientists. This suggests there is a gender dynamic to the production of scientists and engineers, one that favors highly educated fathers and their highly educated wives to confer the social and cultural capital necessary to persist in such training. Additional dynamics worthy of study are the roles of mothers in the scientist-producing household: Forty percent of the mothers of NIH trainees did no paid work while raising the scientists, which is a high rate of labor force non-participation among the highly educated.

In Table 2, I present descriptive statistics about the formal educational attainment of adult men in the United States by race and ethnicity. There is significant within-group race and ethnic differences, lending further support to the idea that scientists are advantaged by the education level of their fathers. Fathers of White children attain significantly higher levels of education than the general adult population of men, a likely reflection of higher educational status of younger rather than older adult White men. Fathers of professors attain significantly higher education than the general population, but significantly less education than the highly selected fathers of White NIH trainees. This general pattern holds for Whites, Hispanics, and Asians:

fathers of science professors and NIH trainees have attained significantly more education than their general population peers. Among Blacks, the key distinction is between the educational levels of the fathers of NIH trainees, and other Black men.

Examining averages between races, we see that Asian men and fathers of Asian scientists and NIH Trainees have the highest levels of education, followed by Whites, Blacks, and Hispanics; Asian men have significantly higher education levels than Whites, while Blacks and Hispanics have significantly lower education than Whites and Asians. Whereas the average White adult man and average father of a White child has had some college education, the average education of the father of a White science professor is close to a master's degree, and the average paternal education of a White NIH trainee slightly exceeds a master's degree. The fathers of Asian NIH trainees (n=40) on average have earned doctoral or professional degrees.

If the "best and brightest" of actual scientists are measured by the educational attainments of their fathers, then it is possible to discern a distinct hierarchy of both parental education and race/ethnicity based determinants of scientific achievement. The socioeconomic and racial/ethnic patterns are not occurring by chance, but as a science policy community we still do not fully understand the mechanisms by which these patterns emerge and are maintained. In the last section, I suggest research questions that may help us to elucidate some of these mechanisms in the hope that better policy mechanisms can be developed to ensure equity and diversity.

Research questions for the Science of Science Policy community

The role of socioeconomic origins in scientific careers is sufficiently under-developed as a domain of science policy research that any number of questions can be formulated that may shed light on how we arrived in this situation as a science policy community, with what consequences, and possibly with some ideas about how to proceed in the future. In this section, I suggest a few "big questions," and give some guidance about which disciplines may be especially well positioned to design studies to answer facets of them.

Historians and Policy Analysts

Why has US federal science policy been so blind to socioeconomic status in the design of its higher education programs in general, and in programs to support graduate education in science in particular? Historians of science or science policy are best positioned to make headway on this issue: How were research assistantships and targeted programs designed without attention to socioeconomic distinctions, and with what consequences? Such work could fruitfully draw from a large body of agency documentation, National Academy of Sciences reports, and political rhetoric at the national level.

Social Psychology and Experimental Design

What role do professors play in perpetuating and exacerbating socioeconomic class differences among their students? A growing body of research in social psychology underscores the role that implicit gender and racial/ethnic biases and stereotype threat operate to create barriers to scientific achievement to members of those groups. Similar designs could be used to address such interpersonal dynamics with regard to socioeconomic status, or better yet, to look at the intersections of race/ethnicity, class and gender. The experimental methodological foundation of many social psychology studies would be especially helpful given the difficulty in sampling discussed next.

Sociology and Quantitative Analysis

In what ways do the intersection of race/ethnicity and gender combine to especially disadvantage students from lower socioeconomic status groups? There is a rich and longstanding body of theory which is referred to as "intersectionality theory," growing out of feminist critical race theory of the 1970s, as well as robust qualitative studies.[18] The ability to study the theoretical implications of intersectionality quantitatively has been limited drastically by the policies of the federal policy establishment and challenges of sampling small populations. I have already noted the lack of attention to the socioeconomic origins of scientists and engineers in the system. Moreover, in the interest of protecting the privacy of small groups of people, NSF suppresses cell sizes smaller than 50, a practice not supported by statistical convention.[19] Thus, we can use national data series to discuss gender, or minorities, but not much can be done with these series to discuss minority by gender (and there is no public data to evaluate the intersection of race/ethnicity, class, and gender). Sociologists are well trained to sort out the thorny sampling problems associated with achieving sufficient statistical power to test small group differences. Furthermore, the discipline's foundation in social and cultural capital theory, and tradition of theoretical and empirical attention to race/ethnicity, gender, and, especially, socioeconomic stratification position it especially well to undertake large-scale studies of intersectionality in the scientific population.[20]

Economists and Policy Analysts

In the zeal for making higher education more affordable for lower income students, what are the science policy consequences of ignoring primary and secondary education financing at the federal level? What does it mean that racial and ethnic diversity in the science establishment is coming disproportionately from the foreign-born and their offspring? The first question is a macro policy question related to US financing of primary and secondary education, and its relationship to creating a population of students prepared for higher education in science: When a large percentage of the young population has no hope of pursuing higher education by virtue of an anemic primary and secondary school system, it seems to be a critical market/public failure of the kind that should concern economists and policy analysts. There is a robust empirical tradition stressing the contributions of the foreign-born to the national science establishment, forming the crux of the "best and brightest" argument in favor of liberal immigration policies for the highly educated. If the nation continues to underinvest in primary and secondary education, and to rely on immigration to cultivate the best and brightest, and to diversify racially and ethnically, what are the negative consequences of such a strategy? Who is helped, who is harmed, and with what possible implications for a future in which immigration to the US becomes increasingly politicized? Science-based immigration policy and education policy in the United States have not been conceptually linked, but perhaps examination of that intersection would be fruitful.

Conclusion

Should the federal government continue to invest in a university-based scientific training system that differentially advantages children from highly educated families? Should the primary racial and ethnic diversification strategy of the federal government rely on immigrant visa policies that favor the highly educated? These are the sorts of policy questions that can only be addressed by more focused research on the intersections of race/ethnicity, class, gender and immigrant status I suggest here. At a minimum, all research on scientific stratification should incorporate the sociologist's queen of ascribed status: parental socioeconomic status, a factor that determines scientific outcomes perhaps to a greater degree than many other life outcomes.

Table 1: Formal Educational Attainment of the US Adult Population, by Gender

	Adults 25+	Men 25+	Fathers of Children	Fathers of Professors	Fathers of of NIH Trainees	Women 25+	Mothers of Children	Mothers of Professors	Mothers of NIH Trainees
Data Source	1	1	2	3	4	1	2	3	4
Years of Formal Education Source									
Less than HS	14.7	15.8	13.1	12.5	6.2	13.8	13.2	13.5	5.6
High school diploma	26.7	27.1	28.6	23.0	13.1	26.3	27.8	32.8	14.5
Some College	26.6	25.3	25.6	5.9	13.4	27.9	30.6	7.9	25.1
Bachelors degree	14.9	15.1	20.3	22.2	21.3	14.6	20.2	23	24.5
Any graduate through Master's	13.8	12.7	7.9	16.4	20.1	14.9	6.5	17.4	22.1
Professional or Doctoral	3.3	4.1	4.6	19.9	25.9	2.5	1.7	5.4	8.4
Average of 6 point scale	2.96	2.94	3.05	3.67	5.01	2.98	2.96	3.14	4.46

Sources:

(1) U.S. Census Bureau, Current Population Survey, 2014 Annual Social and Economic Supplement, Table 3, Table 3. Detailed Years of School Completed by People 25 Years and Over by Sex, Age Groups, Race and Hispanic Origin: 2014

(2) Aud, S., Fox, M., and KewalRamani, A. 2010. *Status and Trends in the Education of Racial and Ethnic Groups* (NCES 2010-015). US Department of Education, National Center for Education Statistics. Washington, DC: US Government Printing Office. attainment and Table 5. Percentage of children ages 6 to 18, by parent's highest level of educational child's race/ethnicity: 2008.

(3) Melkers, J., Welch, E. and Gaughan, M. 2009-2014. " Women in Science and Engineering: Network Access, Participation, and Career Outcomes (Netwise II)," a project funded by the National Science Foundation (Grant # REC-0529642).

(4) Gaughan, M. 2010-2015. "Using the Scientific CV to Study the Effects of Interventions on Research Careers," a project funded by the National Institutes of Health (Grant #R01 GM088731).

Table 2: Formal Educational Attainment of the US Adult Males, by Race

	Average 6-point	Less than HS	HS Diploma	Some College	Bachelor's Degree	Up to Master's	Professional Graduate
Population (Data Source)							
Male Adults 25+ (1)	2.94	14.7	26.7	26.6	14.9	13.8	3.3
NonHispanic Whites							
White Men 25+ (5)	2.94	7.5	30.2	26.4	22.4	8.7	4.8
Fathers of Children (2)	3.28	5.8	28.6	27.2	23.6	9.2	5.6
Fathers of Professors (3)	3.75	10.0	24.8	5.7	21.0	17.4	21.2
Fathers of NIH Trainees (4)	5.12	5.1	13.6	11.5	22.6	19.0	28.0
Black/African American							
Black Men 25+ (5)	2.63	14.7	36.8	28.2	13.6	5.1	1.7
Fathers of Children (2)	2.84	11.2	35.0	32.7	14.2	5.0	1.8
Fathers of Professors (3)	2.76	33.6	24.2	7.7	9.9	16.1	8.5
Fathers of NIH Trainees (4)	4.16	12.0	16.0	24.0	18.0	18.0	12.0
Hispanic							
Hispanic Men 25+ (5)	2.19	34.9	31.1	19.9	9.8	3.1	1.3
Fathers of Children (2)	2.13	41.1	28.6	17.5	8.9	2.9	1.1
Fathers of Professors (3)	3.72	15.8	20.3	3.4	19.3	18.6	22.7
Fathers of NIH Trainees (4)	4.58	7.6	17.7	12.7	27.9	15.2	19.0
Asian							
Asian Men 25+ (5)	3.52	8.1	19.6	17.6	30.2	15.9	8.5
Fathers of Children (2)	3.63	10.5	17.6	15.3	30.7	15.3	10.7
Fathers of Professors (3)	3.42	20.7	13.3	7.8	33.8	10.2	14.2
Fathers of NIH Trainees (4)	5.78	(6)	(6)	(6)	(6)	37.5	30.0

Sources:
(1) U.S. Census Bureau, Current Population Survey, 2014 Annual Social and Economic Supplement,

Table 3. Detailed Years of School Completed by People 25 Years and Over by Sex, Age Groups, Race and Hispanic Origin: 2014

(2) Aud, S., Fox, M., and KewalRamani, A. 2010. *Status and Trends in the Education of Racial and Ethnic Groups* (NCES 2010-015). US Department of Education, National Center for Education Statistics. Washington, DC: US Government Printing Office. Table 5. Percentage of children ages 6 to 18, by parent's highest level of educational child's race/ethnicity: 2008.

(3) Melkers, J., Welch, E. and Gaughan, M. 2009-2014. " Women in Science and Engineering: Network Access, Participation, and Career Outcomes (Netwise II)," a project funded by the National Science Foundation (Grant # REC-0529642).

(4) Gaughan, M. 2010-2015. "Using the Scientific CV to Study the Effects of Interventions on Research Careers," a project funded by the National Institutes of Health (Grant #R01 GM088731).

(5) U.S. Census Bureau, Educational Attainment in the United States: 2014 - Detailed Tables, Table 1. Educational Attainment of the Population 18 Years and Over, by Age, Sex, Race, and Hispanic Origin: 2014

(6) Suppressed because of small cell sizes.

[1] Long, J Scott, Fox Mary Frank. 1995. Scientific careers: Universalism and particularism. *Annual Review of Sociology* 21: 45-71.

[2] Executive Office of the President, National Science and Technology Council, Committee on STEM Education. 2013. Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan. Washington, DC.

[3] Gale, William, Benjamin Harris, Bryant Renaud, and Katherine Rodihan. 2014. Student Loans Rising: An Overview of Causes, Consequences, and Policy Options. Tax Policy Center, Urban Institute and Brookings Institution. Available at http://www.taxpolicycenter.org/UploadedPDF/413123-student-loans-rising.pdf.

[4] National Science Board. 2014. *Science and Engineering Indicators 2014*. Arlington VA: National Science Foundation (NSB 14-01). Available at: http://www.nsf.gov/statistics/seind14/.

[5] National Academy of Sciences. 2011. *Research Training in the Biomedical, Behavioral, and Clinical Research Sciences.* Washington, DC: The National Academies Press.

[6] National Institute of General Medical Sciences. 2011. *Investing in the Future: NIGMS Strategic Plan for Biomedical and Behavioral Research Training*. Available at http://publications.nigms.nih.gov/trainingstrategicplan/.

[7] National Science Foundation, National Center for Science and Engineering Statistics.2012. *Doctorate Recipients from US Universities: 2011*. Special Report NSF 13-301. Arlington, VA. Available at http://www.nsf.gov/statistics/sed/2011/.

[8] National Science Board. 2014. *Science and Engineering Indicators 2014*. Arlington VA: National Science Foundation (NSB 14-01). Available at: http://www.nsf.gov/statistics/seind14/.

[9] National Science Board. 2010. *Science and Engineering Indicators 2010.* Arlington VA: National Science Foundation *(NSB 10-01). Available at:* http://www.nsf.gov/statistics/seind10/.

National Science Foundation, National Center for Science and Engineering Statistics. 2000. *Modes of Financial Support in the Graduate Education of Science and Engineering Doctorate Recipients.* Special Report NSF 00-319. Arlington, VA. Available at http://www.nsf.gov/statistics/nsf00319/.

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[11] Gaughan, Monica, and Barry Bozeman. "Daring to Lead: Bringing Full Diversity to Academic Science and Engineering." *Issues in Science and Technology* 31, no. 2 (Winter 2015).

[12]

U.S. Census Bureau, Current Population Survey, 2014 Annual Social and Economic Supplement, Table 3. Detailed Years of School Completed by People 25 Years and Over by Sex, Age Groups, Race and Hispanic Origin: 2014

Aud, S., Fox, M., and KewalRamani, A. 2010. *Status and Trends in the Education of Racial and Ethnic Groups* (NCES 2010-015). US Department of Education, National Center for Education Statistics. Washington, DC: US Government Printing Office. Table 5. Percentage of children ages 6 to 18, by parent's highest level of educational child's race/ethnicity: 2008.

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U.S. Census Bureau, Educational Attainment in the United States: 2014 - Detailed Tables, Table 1. Educational Attainment of the Population 18 Years and Over, by Age, Sex, Race, and Hispanic Origin: 2014

[13] Please see accompanying document "Gaughan to CSPO Tables 3.1.16."

[14] US Census Bureau, op cit.

[15] US Department of Education, op cit.

[16] Melkers et al., op cit.; data based on 3260 tenured and tenure track professors at 487 universities were asked, "What is the highest level of education your parents have achieved," with branches for mother and father.

[17] Gaughan, op cit.; data based on 503 NIH-funded (between 1985 and 2012) doctoral trainees asked, "What is the highest level of education attained by your father or primary male caregiver?"

[18] Browne, Irene and Joya Misra. 2003. The Intersection of Race and Gender in the Labor Market. *Annual Review of Sociology* 29: 487-513.

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[19] Leggon, Cheryl B. 2006. Women in science: Racial and ethnic differences and the differences they make. Journal of Technology Transfer 31(3):325-333.

In this paper, I follow statistical convention by suppressing cell sizes smaller than five.

[20] This is not to suggest that smaller-scale but well- designed qualitative studies on intersectionality should be abandoned