Work in Progress: An Intersectional Conceptual Framework for Understanding How to Measure Socioeconomic Inequality in Engineering Education

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WIP: An Intersectional Conceptual Framework for Understanding How to Measure Socioeconomic Inequality in Engineering Education

Introduction

Since the late 2000s, there has been a surge of research that focuses on the effect of socioeconomic disadvantage in the American engineering education context [1]–[8]. Through these studies, authors have continued to uncover more about the experiences of socioeconomically disadvantaged students in engineering education, including the role academic institutions play in limiting them from educational attainment. More importantly, these results inform change to institutional policy and classroom pedagogy that further equity in engineering education.

However, few of these studies have begun to question how research positions students in the socioeconomic hierarchy, especially when particular government- or researcher-defined, categories are used to group and compare students at different socioeconomic levels. Ultimately, how groups are chosen based on particular socioeconomic indicators (often income) may determine the type and quality of inferences that can be drawn from the research that follows–that is, it is important for any measurement instrument to be valid for measuring any existing form of socioeconomic inequality and grouping made from that measurement fair and equitable. These concerns raise important questions about how research on socioeconomic can be conducted and the implications of these studies to promote change in engineering education.

A single indicator like income or other commonly used measures for socioeconomic status or positioning cannot measure socioeconomic inequality. These values have a number of other underlying inequalities that affect these more easily observed measures. These inequalities might include race/ethnicity and gender discrimination, which authors Pimpare and Mutua suggest is necessary for understanding the intersectional nature of this phenomena [9], [10]. However, in current measurements [4], [11], there is no consideration of underlying raced and gendered effects influence socioeconomic positioning. The absence of these effects supposes inequality is experienced equally, which a large body of literature indicates is false [12], [13].

In this work, we problematize how quantitative socioeconomic measurements and subsequent groupings perpetuate systematic hegemony through exclusion of other measures of socioeconomic inequality. We problematize how socioeconomic measurement is framed as a deficit model, supposing people lack status or capital and that disadvantage is equally distributed across race/ethnicity and gender. Further we criticize how common large-N measurement has essentialized [14] experiences of socioeconomic inequality to income measures. Then, to begin to address these issues, we present part of a developing framework for measuring socioeconomic inequality, centered in Intersectionality Theory [15] and informed by other theories of race and gender, that can be used in future research to understand how effects of socioeconomic inequality affect income-based access to engineering education.

Underpinnings and Issues of Socioeconomic Measurement

While the landscape of socioeconomic measurement remains broad, there are three more common quantitative measures used for socioeconomic status: individual, school, and neighborhood income. Each of these methods fundamentally ascribes to macroeconomist John Maynard Keynes'

Theory of Consumption [16]. Keynes' claimed that an individual person's consumption, or use of resources, increases as their level of income attainment increases [16]. Additionally, he suggested that differences in income and consumption exist among different occupational classes, and that a person's attitudes of consuming resources would be comparable to others like them in the same class, in the same locality. With a sociological understanding of how people obtain and consume, Keynes claimed that predictions could be made about how a larger market would work, and how people would act within that market [16]. This framing acts as the basis for socioeconomic measurement. For individual socioeconomic measurement, researchers examine the income, occupation, and education of a person and describe how it relates or differs to others in similar or different positions [11]. For neighborhood and school socioeconomic measurement, socioeconomic researchers study how a person compares to others from a similar or different locality than them–such as a county, school, or ZIP code.

The issue with the commonly used measurements for socioeconomic status is that existing understanding of socioeconomic status, like Keynes', are based on a white, male, labor market without acknowledging the complex historical social relations and tensions that exist between members or how socioeconomic experience has moved beyond original market constructions [17]. These original measurements problematically situate socioeconomic experience as universal across many smaller groups that have been excluded from the white, male, affluent comparison group by a series of socially constructed categories like race/ethnicity and gender. As a result, when these measurements are used, they ignore the experiences of less privileged populations, essentializing such experiences as deviation or error in measurement [18]. However, when race/ethnicity and gender are in fact used, they are used as what Paul Holland argues is the problematic use of "causal variables" [18]– that race and gender "cause" differences, when in fact the case is that causal variables act as proxy for measuring larger experiences of inequality that happen at a deeper level. Based on these issues, socioeconomic measurement and its basis needs to shift to take into account systematic inequalities that exist.

In the interest of space, acknowledging our work is much larger than we can describe in this WIP, we present only our work related to the situation of neighborhood socioeconomic inequality. We first provide theoretical background to our additions of race/ethnicity and gender considerations, and then present our neighborhood socioeconomic inequality framework.

Theoretical Framing of Gender, Race, and Intersectionality in the Neighborhood Setting
In this framework, we extend traditional income measurement by highlighting how visible bodied differences of intersectional racial/ethnic and gender identities might be enforced by, or might be used to, reinforce socioeconomic power differences in neighborhoods. Further, we describe how we might disrupt these differences by understanding the experience of socioeconomic inequality as a sum of many parts. We use Connell's theory of gendered structures to describe how physical and discursive power (e.g., physical/sexual abuse), disconnection from obtaining market benefits (e.g., hiring/wage discrimination), emotional connections (e.g., requirements of motherhood), and gendered symbolism (e.g., gendered clothing), relate to socioeconomic inequality in neighborhood measurements [19]. Disadvantaged neighborhood experiences of women may be explained by:

- Power/Emotion - Women often stay in abusive relationships for financial security, and are less financially secure, living in poorer neighborhoods, when they leave [9].

- Symbolism/Emotion – Women in single-mother households have nearly a third of the income of a two-parent household [20], and without child support assistance have a fifth of the purchasing power of a home [21].
- Labor - Women make 75% to 82% the salary of men [22]; transgender women less [23].

We utilize this framework to inform us about how sexist body differences work in the spectrum of status to further support and be supported by socioeconomic inequality.

Considering race, we use Omi and Winant's theory of racial formation which suggests race is a "concept that signifies and symbolizes social conflicts and interests by referring to different types of human bodies" [24, pp. 110-111]. Omi and Winant described how class alone is not enough to understand the experiences of communities of color and that the remaining, unexplained inequities, that are present are due to "[a simultaneous] interpretation, representation, or explanation of racial identities and meanings, and an effort to organize resources along particular racial lines" [24, pp. 125]. This organization makes resources and upward mobility more difficult to obtain for certain groups. Positioning of a neighborhood in which a person of color lives might be explained by:

- Financial Difficulty – Latino/a individuals receive 20% less income in same positions [25]
- Difficulty Obtaining A Job - Black individuals with a "white-sounding name" on their resume were 50% more likely to get a job callback [26].
- Difficulty Obtaining/Owning A Home - Black & Latino/a families are least likely to receive home loans, are least likely to own their homes, and have interest rates over 5% when they do own their homes [9], [27], [28].

Racial/ethnic considerations are historically intertwined with neighborhood socioeconomic inequality and are essential to inform understanding of socioeconomic inequality.

In this framework, we use the above theories of gendered structures and racial formation in conjunction with the long history of Intersectionality theory and praxis described by Collins & Bilge [15], coined by Crenshaw [29]. As theory, we use Intersectionality to describe how different forms of discrimination overlap, bringing with them gendered or racist oppression, as well as additional forms only known at intersections of race and gender, and also frame socioeconomic inequality as a form of intersectional oppression itself [9], [10]. We consider the following an example of how Connell's [19] Omi and Winant's [24] theories intersect and are not additive:

- Welfare Stereotypes – Black women and Latinas have been additionally marginalized by the concept of the "Welfare Queen" which suggests they are "lazy", "promiscuous" and "leeches on society" [30], [31]. The stereotype infiltrates many other forms of Black female and Latina life in ways not known to other groups.

As praxis, we acknowledge the use of intersectionality for furthering social justice by expanding upon the traditional view of socioeconomic inequality situated in sociological theories and measuring socioeconomic inequality in light of power and structures.

Conceptual Framework
Our conceptual framework, shown below in Figure 1, describes how neighborhood considerations of socioeconomic inequality might help inform a larger understanding of socioeconomic inequality in the form of an "index"–a set of variables to more fully describe socioeconomic inequality which

can then be used for further analysis such as structural equation modeling of student data. We note, however, that we have no intentions of this scale being used to rank students socioeconomically. This framework is only meant to be used for further pursuit of social justice for economically disadvantaged populations, such as low-income students in engineering, by replacing previous measurements with this one that accounts for other considerations beyond just income. We claim that any use other than what is proposed violates the basis and ethics of our work.
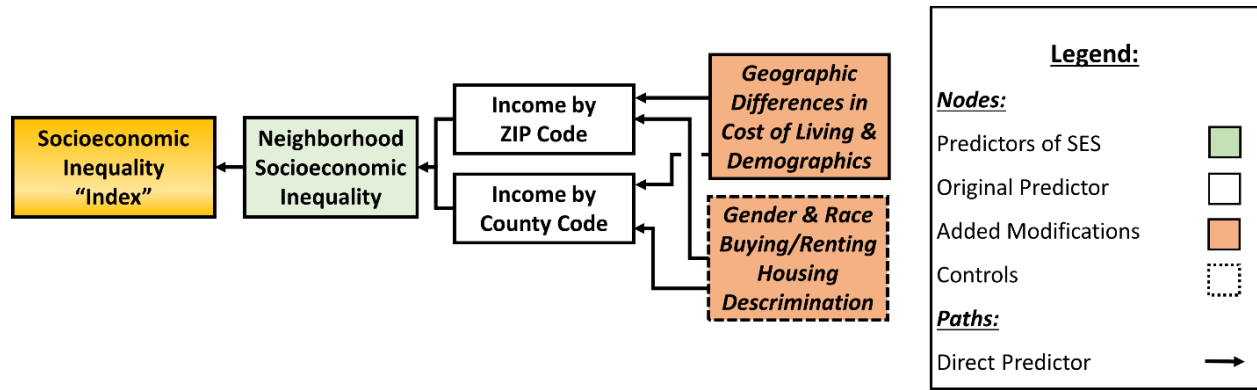

Figure 1. Socioeconomic inequality as informed by neighborhood socioeconomic inequality.

In our framework, we consider neighborhood socioeconomic inequality to be a product of multiple forms of oppression, informed by joint understanding of different localities such ZIP codes and counties, which have histories of discriminatory redlining [27]. Information about income by ZIP code and County Code are both available through the United States Census Bureau [32]. Further, multiple forms of discrimination, for which research and statistics from the United States Census Bureau account, affect neighborhood of residence. These data include cost of living and cost of home obtainment and ownership in different locations across the country. Gendered and raced effects can be included through an incorporation of discriminatory income rates, interest rates, and differences in cost of living. In addition, in measurement, and informed by qualitative understanding, this intersectional conceptual framework may prove to be more useful for future work which requires comparison of socioeconomic differences. This framework works to incorporate more features of socioeconomic experience into measurement, to push away from essentializing quantitative research to a white, male workforce that ignores systems of oppression.

Our Proposed Use and Future Work
Within the neighborhood context, we will attempt to use structural equation modeling to model the factors we have described prior into early measurement frameworks through: (1) the deliberate creation of intersectional comparison groups, and (2) the weighting of variables based on gendered and racialized differences presented in various peer-reviewed literature and government reports. To create intersectional groups, we will follow the procedures outlined by Bahnson et al. [33] to create separate race-gender groups that go beyond controlling for race and gender (i.e. "Black-Women", "Hispanic-Men, "White-Women", etc). Within outside grant projects, we will then assign students' data to these groups based on their individual self-selections of race and gender. Then, to alter or weight our variables in our framework, we will multiply ZIP code- or County-based income values by known wage and interest-rate differences of each students' background. For example, neighborhood income of a self-selecting female student who also self-identifies as Asian would be weighted by a factor of 0.89 to account for the 11% percent difference between the earnings of White Men and Asian Women [34]. In a larger model considering neighborhood,

individual/family/household, and school socioeconomic inequality, adjustments such as these would be considered throughout from a variety of peer-reviewed literature and government sources. These adjusted values would then be used for modeling, such as we will do in future work.

Future work will present the entirety of the model which includes considerations of school socioeconomic inequality, and individual/household inequality. Additionally, future work will use available quantitative data from engineering education populations to validate this model using structural equation modeling. We hope beyond that, we can begin to analyze and reanalyze new and existing data to more concretely understand how socioeconomic inequality promotes inequitable opportunity to experience engineering education at all levels.

Implications and Conclusion
In this work, we have presented a starting point for a more complete framework that decentralizes status determination by ownership of capital as a method of socioeconomic measurement, and instead centralizes socioeconomic inequality. We are examining the amount of socioeconomic inequality a person experiences rather than their socioeconomic status. Our framework keeps Intersectionality Theory forefront considering raced, gendered, and intersectional effects to provide more complete and equitable measures of socioeconomic inequality. This work can be used in engineering education to understand effects of inequality informed by multiple factors.

References
[1]   C. E. Foor, S. E. Walden, and D. A. Trytten, ““I wish that I belonged more in this whole engineering group:" Achieving individual diversity,” *J. Eng. Educ.*, vol. 96, no. 2, pp. 103–115, 2007.
[2]   J. M. Smith and J. C. Lucena, “‘How do I show them I'm more than a person who can lift heavy things?' the funds of knowledge of low income, first generation engineering students,” *J. Women Minor. Sci. Eng.*, vol. 22, no. 3, pp. 199–221, 2016.
[3]   J. M. Smith and J. C. Lucena, “Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering,” *Eng. Stud.*, vol. 8, no. 1, pp. 1–26, 2016.
[4]   J. C. Major, A. Godwin, G. Sonnert, and P. Sadler, “STEM experiences of engineering students from low-socioeconomic neighborhoods,” *2018 ASEE Annu. Conf. Expo.*, 2018.
[5]   J. C. Major and A. Godwin, “Towards making the invisible engineer visible: A review of low-socioeconomic students' barriers experiencing college STEM education,” in *2018 Frontiers in Engineering Conference*, 2018.
[6]   M. K. Orr, N. M. Ramirez, and M. Ohland, “Socioeconomic Trends in Engineering : Enrollment , Persistence , and Academic Achievement,” *Am. Soc. Eng. Educ.*, 2011.

[7]   M. L. Strutz, M. K. Orr, and M. W. Ohland, "Low socioeconomic status individuals: An invisible minority in engineering," in *Engineering and Social Justice: In the University and Beyond*, C. Ballie, A. Pawley, and D. Riley, Eds. Purdue University Press, 2008, pp. 143–156.

[8]   V. C. Lundy-Wagner, C. P. Veenstra, M. K. Orr, N. M. Ramirez, M. W. Ohland, and R. A. Long, "Gaining access or losing ground?: Socioeconomically disadvantaged students in undergraduate engineering, 1994–2003," *J. Higher Educ.*, vol. 85, no. 3, pp. 339–369, 2014.

[9]   S. Pimpare, *A people's history of poverty in America*. New York, NY: The New Press, 2008.

[10] A. D. Mutua, "Introducing ClassCrits: From class blindness to a critical legal analysis of economic inequality," *Buffalo Law Rev.*, vol. 56, no. 4, pp. 859–913, 2008.

[11] G. Sonnert, M. Barnett, and P. M. Sadler, "Individual and neighborhood effects of race / ethnicity and socioeconomic status on participation and performance," *J. Women Minor. Sci. Eng.*, vol. 22, no. 4, pp. 281–307, 2016.

[12] T. Zuberi and E. Bonilla-Silva, *White logic, white methods: Racism and methodology*. Plymouth, United Kingdom: Rowman & Littlefield Publishers, 2008.

[13] R. W. Connell and J. W. Messerschmidt, "Hegemonic masculinity: Rethinking the concept," *Gend. Soc.*, vol. 19, no. 6, pp. 829–859, 2005.

[14] A. E. Slaton and A. L. Pawley, "The power and politics of engineering education research design: Saving the 'Small N,'" *Eng. Stud.*, 2018.

[15] P. Hill Collins and S. Bilge, *Intersectionality*. Malden, MA: Polity Press, 2016.

[16] J. M. Keynes, *The general theory of employment, interest, and money*. New York, NY: Harcourt Brace Jovanovich, 1936.

[17] D. B. Grusky, "Theories of stratification and inequality," in *The Blackwell Encyclopedia of Sociology*, Oxford, UK: John Wiley & Sons, Ltd, 2007.

[18] P. W. Holland, "Causation and race," in *White logic, white methods: Racism and methodology*, T. Zuberi and E. Bonilla-Silva, Eds. Plymouth, United Kingdom: Rowman & Littlefield Publishers, 2008.

[19] R. W. Connell, *Gender: Short introductions*, 2nd ed. Malden, MA: Polity Press, 2009.

[20] E. A. Mulroy and T. S. Lane, "Housing affordability, stress, and single mothers: Pathway to homelessness," *J. Sociol. Soc. Welf.*, vol. 19, no. 3, pp. 51–64, 1992.

[21] I. Garfinkle and S. McLanahan, *Single mothers and their children*. Washington, DC: Urban Institute Press, 1986.

[22] United States Bureau of Labor Statistics, "Women in the labor force: A databook," Washington, DC, 2014.

[23] K. Schilt and M. Wiswall, "Before and after: Gender transitions, human capital, and workplace experiences," *B.E. J. Econ. Anal. Policy*, vol. 8, no. 1, 2008.

[24] M. Omi and H. Winant, *Racial formation in the United States*, 3rd ed. New York, NY: Rouledge, 2014.

[25] Council of Economic Advisors for the President's Initiative on Race, "Economic report of the President: Changing America indicators of social and economic well-being by race and hispanic origin," Washington, DC, 2009.

[26] M. Bertrand and S. Mullainathan, "Are Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market descrimination," *Am. Econ. Rev.*, vol. 94, no. 4, pp. 991–1013, 2004.

[27]   R. Rothstein, *The color of law: A forgotten history of how our government segregated America*. New York, NY: W.W. Norton & Company, 2017.

[28]   D. Desilver and K. Bialik, "Blacks and Hispanics face extra challenges in getting home loans," Washington, DC, 2017.

[29]   K. Crenshaw, "Demarginalizing the intersection of race and sex: a Black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politcs," *Univ. Chic. Leg. Forum*, pp. 139–168, 1989.

[30]   J. Kohler-Hausmann, "Welfare crises, penal solutions, and the origins of the 'Welfare Queen,'" *J. Urban Hist.*, vol. 41, no. 5, pp. 756–771, 2015.

[31]   F. Gilliam, "The 'Welfare Queen' experiment: How viewers react to images of African-American mothers on welfare," *Nieman Reports*, vol. 53, no. 2, 1999.

[32]   United States Census Bureau, "Current population survey," 2019. [Online]. Available: https://www.census.gov/programs-surveys/cps/data-detail.html.

[33]   M. Bahnson, H. L. Perkins, M. A. Tsugawa-Nieves, A. Kirn, and C. Cass, "WIP: A case for disaggregating demographic data," in *2018 American Society for Engineering Education Annual Conference*, 2018.

[34]   K. Miller and D. J. Vagins, "The simple truth about the gender pay gap," Washington, DC.