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Critically quantitative: measuring community cultural wealth on surveys

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ABSTRACT

This study explores the quantitative measurement of Community Cultural Wealth (CCW), an asset-based approach to understanding the experiences of students from systemically marginalized racial/ethnic groups. Grounded in critical race theory, CCW focuses on forms of capital utilized by marginalized populations that are often unrecognized/undervalued by traditional social science research. Most previous studies on CCW have relied on qualitative methods; we argue that quantitative critical race theory, or 'QuantCrit', can complement those studies by statistically specifying assets possessed by students from marginalized populations as a step toward reimagining institutions that elevate their importance. This paper aims to develop a CCW scale to quantitatively explore the concept, while acknowledging the overlaps among and the dynamic nature of the forms of capital emphasized in conceptualization. Findings from exploratory factor analysis are largely consistent with the original CCW framework but suggest some important ways in which the framework can be further developed.

Introduction

Much research on racial inequality in education has taken a deficits-based approach, focusing on how students who are marginalized based on racial and ethnic status lack the resources valued by the dominant group, including hegemonic cultural capital[1], that contribute to success in education (Taylor, Gillborn, and Ladson-Billings 2016). In recent years, however, scholars have increasingly adopted an assets-based approach to educational research. In particular, a number of studies employ the concept of Community Cultural Wealth (CCW) which highlights the ability of students from systemically marginalized populations[2] to overcome social-institutional barriers and persist in education (Yosso 2005). This echoes a rich tradition in social science research on race that highlights the socially constructed and dynamic nature of race (Omi and Winant 2015), and incorporates racialization and power into the conceptualization of cultural capital by differentiating 'non-dominant' from 'dominant' cultural capital (Carter 2003; Cartwright 2022). Following in this tradition, we empirically examine a framework that specifies six

interrelated but distinct forms of cultural resources nurtured through families and communities that students from groups systemically marginalized based on racial and ethnic status possess.

Previous studies on CCW have contributed to rich theory development and exploration of the lived experience of students from marginalized groups, mostly utilizing qualitative methods. Given statistical and demographic methods' deep historical roots in eugenics and the current use of statistics to uphold and sustain racial inequality in contemporary society (Zuberi 2001), the use of qualitative methods is understandable. In fact, sociologists of race have argued that the use of statistics is central to the deficit-based approach that applies methods and scales developed from a White perspective to explain racial inequality (Zuberi and Bonilla-Silva 2008). At the same time, relying solely on qualitative methodology limits the scope of research questions that can be asked using critical race perspectives (including CCW). This tension gave rise to recent calls for increased utilization of quantitative methods guided by the principles of critical race theory, or 'QuantCrit' (Garcia, López, and Vélez 2018).

In this article, we discuss our development of a quantitative CCW scale. Doing so provides an opportunity to apply a critical lens to quantitative methodologies by exploring the CCW framework and critically examining conventional techniques for scale construction and validation. Our exploratory approach contributes to both theory-development and the creation of an instrument that allows researchers to better understand the contours of CCW within student populations. Doing so can illuminate opportunities for institutions to better support students in activating/accessing CCW to persist in their education. In sum, this article examines the following questions regarding the CCW framework:

(1) How can exploratory factor analysis be used in a way that is consistent with critical theoretical and methodological orientations?
(2) How can findings regarding the structure of a quantitative CCW scale help to further develop the theoretical framework?

Background

Critical race theory and community cultural wealth

Critical research was born out of resistance to unequal distributions of power and resources, and the need to critique the status quo in order to galvanize change for a more just society (Kincheloe and McLaren 2005). The principles guiding critical theory emphasize power dynamics between the oppressed and oppressor and posit that research can be used to disrupt power and further social justice (Foster 1986; Sirotnik and Oakes 1986). The development of critical race theory (CRT) drew increased focus on the ways that race and other intersectional social axes of difference perpetuate economic, educational, and social disparities (Bell 1980; Crenshaw 1991; Ladson-Billings 1995; Matsuda 1991). Though CRT started in legal studies (Bell 1980), it has a rich history of analyzing the ways in which educational spaces have perpetuated racism (Ladson-Billings and Tate 1995; López 2003).

CRT is based on six interrelated tenets: 1) the permanence of racism; 2) whiteness as property; 3) counter-storytelling; 4) interest convergence; 5) critique of liberalism; and 6) intersectionality (Ladson-Billings and Tate 1995; Leonardo 2013; Taylor, Gillborn and Ladson-Billings 2016). As the name suggests, CRT, centers race in dominate discourses and fields, such as education, that may otherwise suggest race does not have any explanatory power. CRT posits that racism is embedded within the fabric of society and its institutions. Thus, critical race theorists argue racism is perpetuated unconsciously by merely conducting education as usual (Bell 1980; Gillborn 2008; Taylor, Gillborn and Ladson-Billings 2016).

CRT's focus on counter-storytelling gave rise to the concept of CCW, defined by Tara J. Yosso (2005, 77) as 'an array of knowledge, skills, abilities and contacts possessed and utilized by Communities of Color to survive and resist macro and micro-forms of oppression'. Whereas educational scholars have typically conceptualized cultural capital as the cultural resources valued by the dominant group, Yosso argues that the distinct cultural resources of systemically marginalized populations nurtured by families and communities should be recognized.

Yosso (2005) specifies six interrelated dimensions of CCW: aspirational, linguistic, familial, social, navigational, and resistant. *Aspirational capital* is the belief, derived externally from families and internally from students themselves, in the ability to overcome barriers and persist in their education. *Linguistic capital* is the set of communication skills developed through practicing and switching between different languages or styles of communication. *Familial capital* is the commitment to family/community and skills for building relationships that are developed within families. *Social capital* exists as the networks providing access to instrumental and emotional support for persisting in education. *Navigational capital* is the ability to locate and utilize the information and support necessary to navigate institutions designed within dominant paradigms. *Resistant capital* includes knowledge and skills for resistance developed in the context of structural inequalities/social injustice. This can include self-defeating or conformist strategies (carving out space within racialized social institutions) and transformational strategies (working to change racialized social institutions) (Solórzano and Delgado Bernal 2001).

As Yosso (2005, 77) describes, 'these various forms of capital are not mutually exclusive or static, but rather are dynamic processes that build on one another as part of Community Cultural Wealth'. Building on Yosso's work, a number of qualitative researchers have examined the complex dimensions of the CCW framework. For example, researchers have described the overlap between aspirational and familial capital (Dika et al. 2018) aspirational and navigational capital (Samuelson and Litzler 2016); navigational and social capital; and social capital and familial capital (Denton, Borrego, and Boklage 2020). Researchers have also identified additional forms of capital beyond those specified in Yosso's framework, such as spiritual capital (Huber and Lindsay 2009) transgressive capital utilized as part of queer cultural capital (Pennell 2016), and linguistic social capital developed through networks rooted in a shared common language (Straubhaar 2013).

These studies illustrate the significance of focusing on the complex and interrelated nature of the CCW dimensions, a complexity that is challenging to address using quantitative methods. Even so, utilizing a quantitative approach is important for

expanding the range of questions that can be explored from critical theoretical perspectives. Below, we discuss the utility of quantitative methods for critical scholarship and its potential for further developing the CCW framework.

Critical race theory and quantitative methods

According to CRT, people from marginalized groups are the primary experts on the oppression they face (Delgado and Stefancic 2017). For this reason and others, critical race scholars have focused on centering the voices and qualitative counter-stories of racially and ethnically marginalized individuals (Solórzano and Yosso 2002). Quantitative methods have also been used to uphold and sustain racial and ethnic persecution and discrimination (Black 2012; Zuberi 2001). Therefore, there is epistemological and political tension between critical race theory and quantitative methods. Critical race theory depends on attention to depth and context, while quantitative research is often viewed as independent of context, apolitical, and generalizable. QuantCrit aims to balance the competing goals of critical and quantitative analyses by questioning traditional quantitative approaches, data, fields of research, and the social processes that produce all of these.

Critical race scholars argue racism is endemic to our institutions and unconscious behaviors. The term 'critical' for a critical race theorist is underpinned by the premise that structural racial oppression is the norm, not the exception (Leonardo 2013). Thus, critical researchers challenge the notion that quantitative methods are race-neutral or apolitical. In other words, quantitative data 'have no objective reality beyond the frameworks of meaning and politics that create them' (Gillborn, Warmington, and Demack 2018, 169). QuantCrit takes a principled approach by neither fully rejecting numeric data nor upholding the belief numeric data is supreme or neutral. QuantCrit is guided by the premise that both numbers and our interpretation of them are imbued with social and political meaning. By explicitly articulating and interrogating how racism influences quantitative data, researchers can counter narratives implicitly grounded in whiteness with analyses that are transparent in their social justice intentions (Castillo and Gilborn 2022).

As will be discussed in more detail below, quantitative methods can be used to refine and analytically clarify existing theoretical concepts. Although keeping the meaning of theoretical concepts open-ended is important for their ongoing evolution and development, analytic clarification of theoretical concepts increases their utility for understanding patterns in social processes. Quantitative analysis is useful not because it is 'unbiased' or 'objective', but because the researcher's subjectivity can be easily rendered visible in the research process, from selection of the focal population to the wording of the survey questionnaire and the statistical methods used (Hiramori 2016). The development of our quantitative measure of CCW contributes to ongoing conversations in the field regarding the significance of QuantCrit as a methodological approach (Garcia, López, and Vélez 2018).

Quantification of community cultural wealth

Our work builds on a small number of previous studies that have examined CCW quantitatively. For example, Dika et al. (2018) utilized a nine-item CCW scale to examine

the role of CCW in persistence in engineering. Braun et al. (2017) integrated perspectives of their focal population and exploratory factor analysis to develop a Deaf Community Capital scale. While both studies make important contributions, Sablan (2019) more explicitly addresses the epistemological conflict between critical race theory and quantitative methods reviewed above. In demonstrating the utility of quantitative methods in critical race studies, Sablan (2019, 187) develops 'nondominant cultural capital scales', consisting of aspirational, familial, navigational, and resistant capitals. This is the most comprehensive development of a quantitative CCW scale, but addresses only four of the six forms of CCW that Yosso (2005) proposed.

Our research builds from Sablan's by further developing a quantitative CCW scale to include all six dimensions specified in the CCW framework and further interrogating standard approaches to quantitative scale validation. The resulting instrument can be used by researchers to answer inherently quantitative questions, such as: what forms of CCW are most commonly possessed/utilized by students from systemically marginalized groups? How does this vary based on interactions between race, gender, sexual orientation, and disability status? How does the presence/utilization of CCW vary across disciplines? While answering these questions is beyond the scope of the current article, our development and validation of the CCW scale lays the foundation. Once these types of questions are answered, researchers can use the findings to examine how institutions are responsive to and center the CCW of systemically marginalized groups. For example, how can admissions policies (both at the university level and among competitive majors) reflect an increased value on the forms of CCW systemically excluded under the current system? How can knowledge about the distribution of CCW inform pedagogical/curricular strategies to engage students' CCW?

This tool can be used by institutions to systematically re-evaluate the ways in which they are valuing students' assets and 'move beyond reductionist notions of what counts and does not count as valuable cultural capital' (Sablan 2019, 187). Our intention for future use of this scale is to make visible to institutions the assets that students possess and support the institutions in making sure that students' CCW is valued and elevated. We actively discourage use of this scale to compare students from marginalized populations to each other or to focus on how to enhance the CCW of those with 'less' of it. Instead, the scale should be used to continue moving away from deficit-based frameworks and focus on institutional interventions, as one of the core tenets of QuantCrit scholarship is 'honoring the rich cultural histories and alternative ways of knowing, being, and doing' (Tablon and Thomas 2023, 778).

Data and methods

Study context

As researchers committed to critical interpretations of social processes, we acknowledge that our positionalities shape the motivation and methodology of our research (Milner 2007). We recognize that, though members of our research team all have identities that are marginalized or not depending on the spaces we are in, none of us share the specific identity profile of students that were the focus of our study: racially/ethnically minoritized undergraduate students in STEM (science, technology, engineering, and

mathematics). One of us is Japanese, one of us is Afro-Panamanian, two of us are White, and we all have graduate training in the social sciences. Throughout the research process, we have reflected on the ways that our identities and our formal methodological training inform our approach, particularly our role in relation to interview participants and the analytic strategies we employed.

Our study was conducted in collaboration with the Pacific Northwest Louis Stokes Alliance for Minority Participation (PNW LSAMP), an NSF-funded project aimed at increasing degrees granted to undergraduate students from racial/ethnic groups marginalized in STEM (African American/Black, Hispanic/Latinx/a/o, American Indian/Alaskan Native, and/or Hawaiian/Pacific Islander). While LSAMP programs vary widely across the country and within the nine schools that are part of the PNW Alliance, they aim to support students by strengthening academic and research skills (Clewell et al. 2006). As such, LSAMP programs were designed to address deficits rather than transform institutions. In fact, some argue that federally funded, top-down diversity initiatives are sites for assimilation not resistance (McGee 2020). However, practitioners and researchers working with LSAMP and similar efforts to improve diversity, equity, and inclusion in education are increasingly recognizing the need for structural change. Exploring CCW in this context encourages a shift away from deficit thinking and makes room for further conversation about the role of student support programs in advocating for institutional policies and practices that elevate the value of CCW.

Our research focuses specifically on students in STEM, an area in which educational debt (Ladson-Billings 2006) is particularly pronounced. Although students who are racially and ethnically marginalized in STEM fields are just as likely to enter STEM majors as their white counterparts (Xie, Fang, and Shauman 2015), they are less likely to be awarded a STEM bachelor's degree (IPEDS 2019). Moreover, racial and ethnic inequality in degrees granted is more pronounced in STEM fields than in non-STEM fields (Riegle-Crumb, King, and Irizarry 2019). These disparities are not necessarily driven by academic performance. For example, research shows that white men who receive low grades in introductory STEM courses are more likely to continue in their STEM majors than minoritized women who receive similar grades (Hatfield, Brown, and Topaz 2022).

Study procedures

Development of our initial CCW survey instrument began with a review of qualitative research on CCW, existing CCW survey instruments, and interviews with 11 PNW LSAMP students.[3] These interviews helped us identify language and additional nuance around students' conceptualization of their own CCW.[4] Six of the 11 interview respondents participated in follow-up cognitive interviews, which involved investigating whether survey questions serve their intended purposes (Willis 2005).

We piloted our original 81-item CCW survey instrument in 2020 as part of the annual PNW LSAMP student evaluation survey. Our analysis of pilot data informed further refinement of the survey, resulting in a 69-item instrument included on the 2021 student survey. Our utilization of exploratory factor analysis to determine which survey items to retain is described below. The 2021 evaluation survey was sent to 7,198 LSAMP-eligible students, who are undergraduate students from racial/ethnic groups marginalized in

STEM enrolled in one of the nine schools that form PNW LSAMP. A total of 968 students responded, and 742 consented to participate in the social science research section. Our findings regarding theoretical and methodological implications for further development of the CCW framework are based on this sample. A table with demographic characteristics of the 742 survey participants is available in this article's supplemental material.

Exploratory factor analysis

In this section, we describe our statistical analyses in detail to be transparent about our decisions and sources of subjectivity (Henson and Kyle Roberts 2006). We utilized exploratory factor analysis (EFA) to examine the latent structure of CCW, first with the 2020 pilot data and subsequently with the 2021 study data. This analytic approach requires complete cases, so researchers must choose to either delete all cases with missing values or impute missing values. This limitation created a methodological and theoretical puzzle, because our survey included a set of questions geared specifically toward students who speak more than one language. It did not make sense conceptually to impute values for the multilingual survey items for monolingual students, but the unique skills and knowledge of people who speak multiple languages is an important piece of the CCW framework. For this reason, we conducted two parallel exploratory factor analyses for each dataset: one that includes all students and excludes responses to the multilingual questions, and another that includes all questions but only the 435 multilingual students.

Specifying the number of factors extracted in EFA is both a methodological and theoretical choice. Yosso's original CCW framework included six dimensions which intersect and overlap in a variety of ways. Subsequent studies utilizing CCW have further refined the framework by examining additional sub-dimensions and complex relationships between dimensions. Therefore, rather than extracting six factors to represent the six theoretical CCW dimensions, we chose to empirically derive the number of factors from the data. We did this in hopes of building deeper understanding of the distinction and relationship between CCW dimensions. We used Horn's parallel analysis (Horn 1965) and Velicer's minimum average partial (MAP) test (Velicer 1976) to determine the number of factors, rather than the more commonly used Kaiser's rule (Kaiser 1960) or Cattell's scree test (Cattell 1966), due to concerns about the arbitrary nature of these methods (Fabrigar et al. 1999; Zwick and Velicer 1986).

The number of factors suggested by parallel analysis and Velicer's MAP test for both samples ranged from 10 to 13. We used these suggestions as a starting point, but conducted EFAs with varying numbers of factors for both samples. After reviewing the factor loadings of individual survey items, we made theory-driven decisions to establish the final number of factors. For example, an EFA resulting in two distinct factors for the external motivation/inspirational dimensions of aspirational capital (one derived from teachers and one derived from siblings/cousins) is not theoretically justified since these are conceptually similar enough to reflect one factor. Our deliberation between empirical findings and theory resulted in a 10-factor structure for the all-student sample and a 12-factor structure for the multilingual-student sample.

Following research illustrating the interrelated nature of CCW dimensions, we utilized an oblique rotation method (direct oblimin rotation), rather than an orthogonal method that assumes the factors are uncorrelated. Although there is no standard threshold for

statistically determining the composition of factors, a factor loading of .40 is a common threshold (Henson and Kyle Roberts 2006). Using this guideline, we deleted the items that did not have a factor loading of .40 or higher for any of the factors identified by the exploratory factor analysis for either the all-student sample or the multilingual-student sample. A total of 12 items were deleted in this process. A full list of the final 69 CCW items we included in the 2021 survey along with all survey items that were cut in this process can be found in this article's supplemental material.

We took the same approach when analysing data from the 2021 student survey. We first used parallel analysis and Velicer's MAP test to determine the number of factors, which ranged from 9–13 for the two samples. Based on both theoretical reasoning and methodological recommendations to prioritize Velicer's MAP test for the purpose of developing a scale (Hori 2005), we set the number of factors to 9 for the all-student sample and 10 for the multilingual-student sample. After removing the questions with factor loadings less than .40 for both samples, we re-ran the factor analysis until all retained questions had factor loadings greater than .40 for at least one sample. We also deleted items that had factor loadings greater than .40 for more than one factor. We recognize that our decisions about which factors to retain were strongly influenced by standard convention and have implications for the critical intentions of our research, as discussed in our findings below. Overall, our analyses suggest the ten-factor CCW framework described in the following section.

Results

As shown in Table 1, our findings regarding the latent structure of the CCW framework are closely aligned with Yosso's conceptualization, though we found that several of our survey items loaded onto different latent constructs than anticipated. In particular, many items intended to measure aspirational capital were more strongly associated with underlying familial and navigational constructs. We also found that familial, linguistic, and resistant capital included distinct sub-dimensions. While we left open the possibility that the latent construct of the CCW framework as a whole could be different for multilingual students, our findings were largely consistent when analyzing the full sample and the multilingual subsample.[5] Factor loadings for all students and multilingual students are available in this article's supplemental material. Below, we describe the 10 latent factors (CCW dimensions) we identified as they relate to Yosso's original six CCW dimensions.

Our original CCW survey instrument included 14 items intended to measure aspirational capital. Yosso describes aspirational capital as a 'culture of possibility', whereby families believe and instill the belief in their children that they can transcend current circumstances and institutional or personal barriers they face (Holland 2017; Huber and Lindsay 2009; Yosso 2005). Therefore, our survey included questions about hopes and dreams for the future, confidence in ability to overcome barriers, and motivation/ inspiration for pursuing a college degree. Our approach to EFA allowed survey items to load onto a range of latent constructs rather than a pre-specified set of latent constructs. This allowed us to examine the extent to which our pre-specified notions regarding the boundaries of each CCW dimension were consistent with their boundaries as implicitly experienced by students. Using this approach, we did find support for

Table 1. Community cultural wealth dimensions.

Original CCW dimensions	Latent structure of CCW produced through EFA	
Familial	Cultural familial	Connection to family, cultural heritage, and histories
	Aspirational familial	Encouragement and inspiration to persist in education derived from immediate family
Aspirational	Aspirational	Encouragement and inspiration to persist in education derived from role models in extended family/community
Navigational	Aspirational navigational	Belief in dreams for the future and ability to locate and utilize the information and support necessary to navigate institutions designed within dominant paradigms
Linguistic	Expressive linguistic	Ability to communicate through creative forms of expression
	Communicative linguistic	Communication skills developed through practicing and switching between different styles of communication
	Multilinguistic	Communication skills developed through practicing and switching between different languages
Social	Social	Networks that provide access to instrumental and emotional support for persisting in education
Resistant	Narrative resistant	Knowledge of structural inequalities/social injustice and desire to create a more just society
	Motivational resistant	Dedication to increasing representation within field of study

a standalone aspirational factor aligned solely with items relating to external sources of inspiration (see Figure 1). However, our approach also resulted in several of the aspirational capital items loading onto latent factors alongside navigational and familial capital items. This finding is consistent with prior research illustrating the interrelated nature of aspirational, familial, and navigational capital.

Several of our survey items intended to measure the internal motivation aspects of aspirational capital loaded onto a factor primarily comprised of items intended to measure navigational capital. This finding aligns with a previous study that showed, when discussing persistence in higher education, students frequently express their aspirations and ability to overcome barriers in terms of both skills (navigational capital) and disposition (aspirational capital) (Samuelson and Litzler 2016). We have termed the latent factor that includes both dispositional and skills-based aspects of persistence in face of barriers *Aspirational Navigational Capital*. As shown in Figure 2, this form of capital is indicated by both students' hopes and dreams for the future as well as belief in their ability to overcome barriers to reach them.

Our analysis also revealed a conceptual overlap between aspirational and familial capital. As found in prior studies using the CCW framework, aspirational capital is intertwined with familial capital in that family histories involving instances of struggle and perseverance can provide inspiration and motivation for students to succeed. These family narratives can be one strong source of aspiration, as can strong familial bonds and commitments. We find that, rather than comprising two distinct forms of capital, close family bonds and the aspirational capital they produce indicate a shared latent construct. As shown in Figure 3, survey items
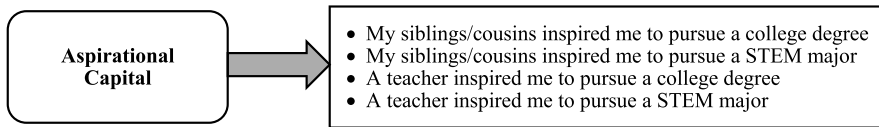
Aspirational Capital
- My siblings/cousins inspired me to pursue a college degree
- My siblings/cousins inspired me to pursue a STEM major
- A teacher inspired me to pursue a college degree
- A teacher inspired me to pursue a STEM major

Figure 1. Aspirational capital.

Aspirational Navigational Capital

Aspirational
- I believe that my dreams for the future are possible
- I am hopeful for my future
- I consider myself an ambitious person
- I see myself pursuing a career in STEM
- I maintain my hopes and dreams for the future, even when confronted with barriers

Navigational
- Even when presented with obstacles, I am able to find the resources I need on campus
- I have developed strategies to deal with difficult people at the university
- I have developed strategies to navigate difficult situations at the university
- I take advantage of the academic opportunities that I am presented with
- I am confident searching online for information about college resources
- I am able to plan ahead to realize the goals I set
- I am good at time management

Figure 2. Aspirational navigational capital.

relating to encouragement from family and inspiration from parents (not siblings/cousins) loaded onto the same factor as items relating to connections to and support from immediate family. We have termed this dimension *Aspirational Familial Capital*. This type of capital reflects the motivational aspects of familial capital that emerge from close family relationships. This aligns with Sablan's finding that aspirations derived from family do not empirically fit the latent aspirational capital construct, although they are included as part of Yosso's definition of aspirational capital (Sablan 2019; Yosso 2005).

While we find that some aspects of familial capital as conceived by Yosso do not align with a latent factor distinct from aspirational capital, others do. Yosso's original definition of familial capital was much more expansive than its operationalization throughout much of the CCW literature, which has focused primarily on connection to and support from immediate family members. We aimed to measure both connection and support from immediate family and those aspects of familial capital relating to cultural knowledge and a broader understanding of family. Familial capital as defined by Yosso includes a broad conceptualization of family that extends to 'aunts, uncles, grandparents, and friends who we might consider part of our *familia*' (Yosso 2005, 79). Our analysis did not show that survey items relating to community connections or extension of family to include broader communities were empirically aligned with any of our 10 factors. However, as shown in Figure 4, we did find support for a *Cultural Familial Capital* dimension that is indicated by items relating to connection with extended family and the transference of family stories and traditions.
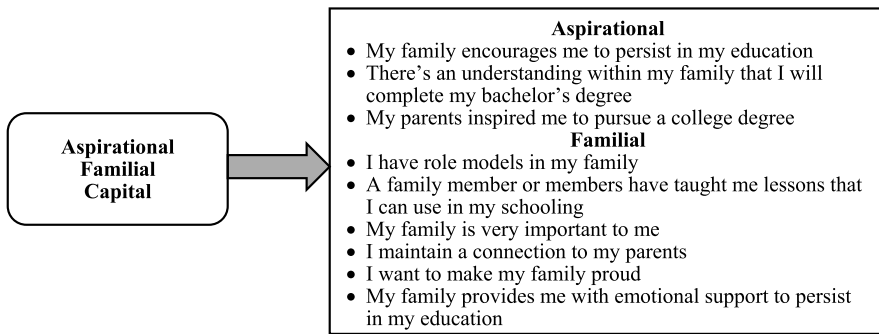
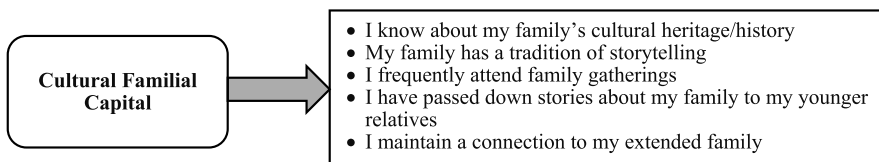**Figure 3.** Aspirational familial capital.

Figure 4. Cultural familial capital.

We find that linguistic capital can be understood as three distinct dimensions: expressive linguistic capital, communicative linguistic capital, and multilinguistic capital (see Figure 5). Most CCW researchers, including Yosso, have primarily discussed linguistic capital as the skills and knowledge developed by multilingual students acting as 'language brokers' (Huber and Lindsay 2009). However, Yosso's CCW framework allows space for exploring other forms of communication aside from language, and some researchers have interpreted it in a way that extends to students who are not multilingual. For example, a previous study quantitatively examining CCW defines linguistic capital as '[t]he ability to switch communication styles or languages on the basis of the environment (e.g. academic and non-academic)' (Dika et al. 2018, 2) Our analysis suggests that multilinguistic capital is a distinct form of capital implicitly identified by multilingual survey respondents, and that linguistic capital is further divided into two sub-dimensions : the ability to express oneself creatively (expressive linguistic capital) and the ability to code-switch/communicate with a variety of audiences (communicative linguistic capital).

Our findings regarding the composition of a latent social capital construct are consistent with prior research that frames social capital as the instrumental and emotional benefits that flow from interpersonal relationships (Dika et al. 2018; Holland 2017; Liou, Antrop-González, and Cooper 2009; Yosso 2005). As shown in Figure 6, social capital is indicated by nine survey items relating to the benefits derived from a variety of social connections.

Our analysis revealed two latent factors indicating sub-dimensions of resistant capital, which are similar to those identified by Sablan: '(1) identification of oppression in society and (2) motivation to transform oppressive structures' (Sablan 2019, 195). As shown in Figure 7, we found that the recognition/acknowledgement of systemic barriers/
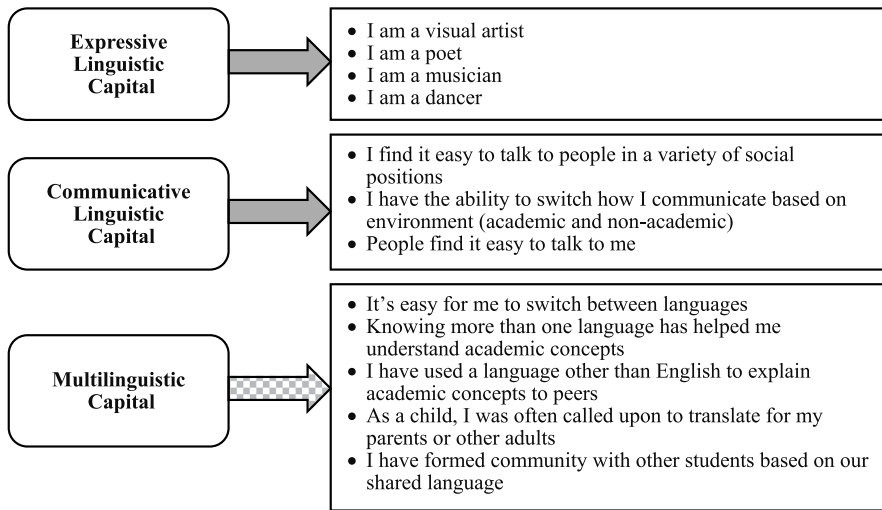
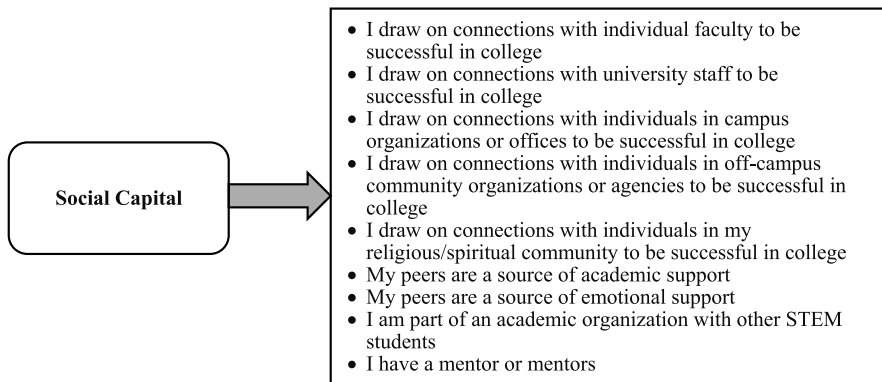**Figure 5.** Linguistic capital.

Figure 6. Social capital.

discrimination (narrative resistant capital) is a separate latent construct from the more action-oriented activation of these beliefs as motivation to pursue a STEM degree (motivational resistant capital). Motivational capital is closely related to aspirational capital; students hold onto dreams despite barriers in the hopes that they can succeed and serve as a role model for other young people with similar backgrounds. The difference, as revealed in our analysis, is that aspirational capital takes the form of direct support/inspiration from a close inner circle (aspirational capital, aspirational familial capital) and commitment to developing/discovering the tools to overcome barriers (aspirational navigational capital); whereas motivational resistant capital is aspiration derived from commitment to increasing diversity of STEM fields. Motivational aspirational capital is similar to 'successive role modeling' – the desire to increase the number of Latinx students in engineering in order change the face of engineering (Revelo and Baber 2018).
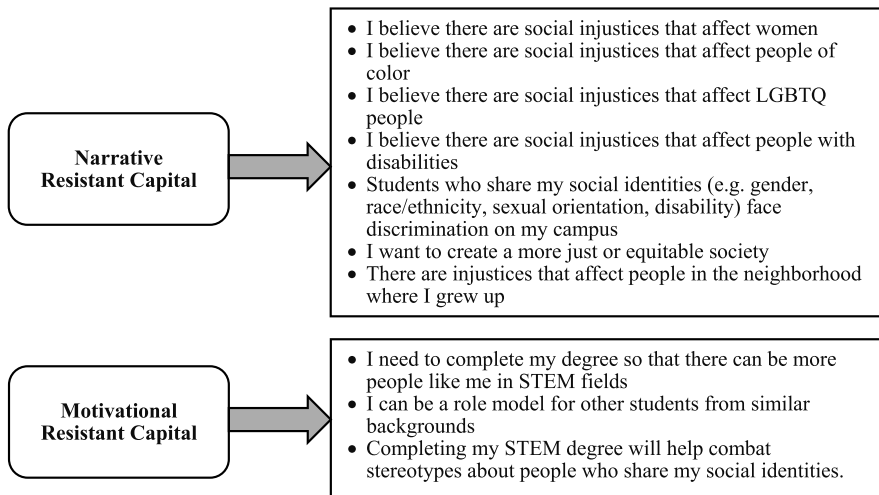
Figure 7. Resistant capital.

Items related to structural change/transformation (e.g. I challenge university practices that seem unjust) did not load onto any latent constructs in our pilot survey, and were thus excluded from the findings presented here. While the literature suggests that working toward structural transformation is an important aspect of resistant capital, our findings show that resistant capital manifests more as conformist resistance (Solórzano and Delgado Bernal 2001). However, we recognize that our methodological choices to omit questions that had a factor loading of less than .40 have important theoretical implications that should be further interrogated based on the tenets of QuantCrit. We made an empirical choice guided by statistical convention and missed an opportunity to explore biases introduced by our own methodological training in the social sciences and the sample from which our findings were produced. Given the existing racialized connotations of pursuing a college-level STEM education, it is likely that our sample is systematically less likely to express transformative resistant capital.

Discussion

Our research is motivated by QuantCrit's call for increased use of quantitative methods to explore questions driven by critical race theory, and the acknowledgement that quantitative methods are inherently subjective and can be used critically if there is intention and transparency regarding methodological choices. Our findings suggest some important ways in which the CCW framework can be further developed using quantitative methods. Specifically, our use of EFA allowed us to examine the contours of the CCW framework as implicitly defined by a large sample of students from racial/ ethnic groups systemically marginalized in STEM fields. We found that the latent factors producing patterns of response to a survey derived from Yosso's six-dimension CCW framework were largely aligned with the original structure and subsequent qualitative research detailing its complexity.

Our analysis contributes to further specification of the conceptual framework and identification of boundaries around the interconnected CCW dimensions. Specifically, some survey items expected to measure aspirational capital were more strongly associated with familial and navigational capital constructs. As suggested by qualitative research using the CCW perspective, this indicates the interrelated nature of these dimensions. The EFA also indicated that familial capital, linguistic capital, and resistant capital all included multiple sub-dimensions. Additional examination of correlations among factors also showed that, for both the all-student sample and the multilingual student sample, the aspirational navigational capital factor derived from our analysis was correlated with social capital; cultural familial capital was correlated with aspirational familial capital; and communicative linguistic capital was correlated with aspirational navigational capital (the correlation matrices are available online: [URL redacted for anonymity]). This highlights the benefit of QuantCrit to expand upon theoretical constructs derived from qualitative work.

Throughout our research process, we have engaged in reflection regarding our methodological choices and the extent to which they aligned with our orientation guided by QuantCrit. This includes decisions about the construction of data collection instruments; participant compensation; selection of statistical methods; strategies for dealing with missing data; and interpretation of our findings. We have aimed to describe in detail the statistical/methodological decision points we made and why we made those decisions. For example, utilizing oblique rather than the more conventional orthogonal rotation allows us to account for the interrelated/overlapping nature of the CCW dimensions as the framework has been theorized (Sablan 2019).

We also made difficult decisions regarding the retention/exclusion of survey items which resulted in the omission of some of the more transformational elements of resistant capital. We remain curious and open to further exploration of this choice, due to the action-oriented intention behind CRT research. A path for future research could be to re-introduce the transformational elements to the survey instrument and more closely examine if and how the culture and practices of different fields of study draw students with different orientations toward resistance. In order to be transparent about our work and encourage critique, we have included all survey items in the in this article's supplemental materials so that other scholars can clearly see what is included and not included in each of our latent factors.

Utilizing a QuantCrit approach provides an opportunity to create a more complex understanding of the contours of CCW among STEM students from systemically marginalized groups. Because we are interested in transforming systems to be more equitable, we believe this work opens doors to developing new insights about how educational institutions can support and promote these distinct forms of capital. Though these questions are beyond the scope of the current study, quantitative documentation of the CCW possessed by marginalized students on college campuses can help re-frame discussions about educational equity in terms of mismatch between student assets, institutional policies, and educational debt rather than student deficits in relation to existing paradigms. An improved understanding of the constructs and sub-dimensions of CCW can help institutions to critically examine the experiences and traits that they are currently valuing in their students and make conscious shifts to elevate the value of capital that marginalized students possess and utilize in college. This instrument can also

be used to examine variations in the extent to which the culture and practices of different academic disciplines attract and retain students with different constellations of CCW.

This study focused on STEM students from racial/ethnic groups marginalized in STEM because we believe it is important to work toward eliminating the opportunity gap in STEM, but we recognize that STEM students may be different in important ways from non-STEM students and thus the results shared here may not hold for broader populations. Further, our analysis of a multilingual sub-sample alongside the analysis of the full sample revealed that the latent CCW structure was largely the same for both groups, but we recognize that theoretical constructs can manifest differently among different subpopulations. There are benefits and drawbacks to developing standard tools to be used across groups, versus tools that are tailored to specific groups.[6] We have provided an instrument that can be used across groups, with the aim of measuring variation in experience so that institutions can assess their policies and practices to better value students' CCW. We hope that this CCW scale can be tested in the future with a variety of populations to assess its broader generalizability and validity.

Notes

1. Cultural capital research in the United States has largely focused on 'knowledge of or facility with 'highbrow' aesthetic culture' (Lareau and Weininger 2003, 567). However, Bourdieu sought to provide a structural critique of social inequality by conceptualizing cultural capital as relational and context-specific (Bourdieu and Wacquant 1992). For Bourdieu, 'cultural practices derive their meaning and significance not from their intrinsic qualities but from the ways in which they are related to one another within different fields and the relationship that they have to different social positions within and across those fields' (Bennett et al. 2009, 3).
2. We define systemically marginalized populations as those excluded from full participation in social institutions, including people who are Black/African American, Native American, Latinx, Pacific Islander, women, sexual and gender minorities, and people with disabilities, among others. The exact groups included may vary based on which social institutions are discussed.
3. Our study design was reviewed by the University of Washington Institutional Review Board and deemed exempt from human subjects approval and continuing review based on exempt category 3 (benign behavioral interventions).
4. The interview protocol is available in this article's supplementary materials.
5. Although most survey items were the same between the full sample and the multilingual sample, there were a few slight differences. An item 'I see myself pursuing a career in STEM' was part of aspirational navigational capital only for the multilingual sample, and two items 'I have developed strategies to deal with difficult people at the university' and 'I have developed strategies to navigate difficult situations at the university' were part of aspirational navigational capital only for the full sample. An item 'A family member or members have taught me lessons that I can use in my schooling' was part of aspirational familial capital only for the full sample. An item 'I draw on connections with individuals in my religious/spiritual community to be successful in college' was part of social capital only for the full sample. The factor loadings for all of these items were all at least .34 for both samples, only slightly below the .40 cutoff we set. In addition, the item 'Even when presented with obstacles, I am able to find the resources I need on campus' loaded more strongly onto social rather than aspirational navigational capital for the multilingual sample. We elected to retain this item as part of the aspirational navigational factor for theoretical reasons.
6. A notable example includes a QuantCrit study of the Collaborative Learning Expansion Set (CLES) instrument conducted to highlight and center Black STEM student experiences (Priddie 2021).

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