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| Research Article

Validating an instrument for measuring community cultural wealth with biology majors at a Hispanic-serving institution

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ABSTRACT Boosting underrepresented student persistence in STEM majors has been of interest for several years. Prior research has explored various factors that may influence student success and persistence in STEM majors. Specifically, some of these studies have employed Yosso's community cultural wealth framework to explore how a student's cultural wealth may link to certain outcomes. Most of these studies have taken a qualitative approach when exploring cultural wealth and less adopt a quantitative approach. Using biology students in an introductory biology class during the fall (n = 303) and spring semesters (n = 215) at a large Hispanic-serving institution in the southeastern United States, this study seeks to contribute to the literature by validating a previously constructed instrument with a new population. An exploratory factor analysis (EFA) was conducted using principal axis factoring and an oblique rotation. EFA results revealed 10 dimensions of cultural wealth. Additionally, confirmatory factor analysis confirmed that the model produced properly measures the constructs as intended. Overall, the final 56-item instrument used in this study was validated and can be used for measuring cultural wealth in similar populations.

KEYWORDS Hispanic-serving institution, cultural wealth, Latin*, exploratory factor analysis, confirmatory factor analysis

Supporting underrepresented students in STEM

Nationally, there continues to be a focus on increasing the number of students graduating with STEM degrees, especially those from underrepresented backgrounds. As such, discussions around the pathways into STEM and the importance of increasing underrepresented student persistence continue (1). Underrepresented students in STEM are less likely to obtain a bachelor's degree than represented students (2, 3). Pathways into STEM have been shown to be especially problematic for those who identify as Hispanic or Latin* (4–6). While there are many terms used to capture the social identity of those with heritage from Latin America (Latino, Latina, Latinx, etc.), this study will use Latin* with the aim of being inclusive of the various terms that can be used as recommended by Salinas (7). Hispanic- and Latin*-identifying people, as a demographic group, are recognized as the fastest-growing group in the United States (8). As the population increases, so do the opportunities to support those who enter a pathway into STEM. Recognizing the various factors that influence the persistence of Latin* students in STEM majors can lead to more desirable long-term outcomes (9). Without adequate adjustment to the current systemic practices in education, institutions may unintentionally prevent Latin* students from entering STEM. In turn, the workforce will miss out on the opportunity to grow from the cultural knowledge and perspectives that Latin*- or Hispanic-identifying individuals bring. If the United States is to remain a powerhouse in STEM, it cannot be done without diverse perspectives and voices in the field.

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Theoretical framework

This study draws on the framework of community cultural wealth (CCW). This framework was developed as an asset-based approach to how we view "cultural capital" (10). Cultural capital can be seen as what is "valued" and needed to succeed in the culture of the dominant group (11, 12). In comparison, deficit mindsets tend to position certain groups, such as families of color, as being at an automatic disadvantage. The CCW framework acknowledges that families of color do in fact have a certain "wealth" of capital which in turn can influence their success (10). Specifically, Yosso's framework describes six forms of capital:

1. Aspirational capital—The ability to hold on to long-term goals and dreams, even when faced with adversity.
2. Familial capital—Knowledge or wisdom that is accrued through familial connections or heritage.
3. Linguistic capital – —Abilities pertaining to forms of expression/communication such as language or artistic abilities.
4. Navigational capital—Skills or assets needed to navigate a specific institution or context.
5. Resistant capital – —Capital related to resisting or pushing back against racist systems or structures.
6. Social capital—Capital acquired through social networking in the form of peers, communities, or other social entities.

These sources of capital allow different individuals to progress toward their goals even when faced with unexpected challenges or oppressions. For example, a study found that black students may find themselves communicating differently when speaking to a professor of a different identity, whereas they may feel more comfortable and speak more "like themselves" when talking with a black professor (13). This code-switching ability can be seen as an asset or linguistic capital that the student has that allows them to navigate through certain situations.

Even with the current forms of capital that make up CCW, some have argued for the inclusion of other forms of capital to this framework such as spiritual capital which is rooted in a student's beliefs (14, 15). Today, this framework is still seen as an important tool in exploring how students navigate and persist through unsupportive contexts and institutions of higher education.

Quantitative explorations of community cultural wealth

Most studies that employ CCW employ a qualitative approach (16). As such, far less studies have taken a quantitative approach toward exploring cultural wealth in students. Some of these studies have sought to develop instruments to measure CCW with their respective populations (17–19). A more recent study aimed to build on the work of Sablan (19) by developing an instrument that measured the six forms of capital that make up CCW (20). The instrument developed from this study was found to measure 10 dimensions of CCW. In addition to reporting their findings from an exploratory factor analysis (EFA), they stated the goal of seeing this tool tested and validated with different populations. As such, the study presented in this manuscript aims to test this scale with a new population to further validate the tool they developed. Additionally, this study seeks to build on Hiramori et al. (20) by conducting a confirmatory factor analysis (CFA) in addition to the EFA.

METHODS

Participants and university context

This instrument validation took place at a large Hispanic-Serving, R1, institution in the southeastern United States and was approved by the institution's Institutional Review

Board (IRB-23-0428). Utilizing Qualtrics software, the survey was first administered in the fall 2023 semester. This survey contained demographic questions as well as 76 questions aimed at measuring the dimensions of CCW adapted from Hiramori et al. (20). It is worth noting that the original scale in Hiramori et al. (20)'s study included questions targeting multilingual students. For the results below, we did not include those questions so that we could explore all participants in the factor analyses regardless of whether they spoke multiple languages. All the capital-related questions were answered on a six-point Likert scale (1 = strongly disagree, 2 = moderately disagree, 3 = disagree, 4 = agree, 5 = moderately agree, and 6 = strongly agree). Based on the findings regarding the underlying factor structure CCW, the survey was modified and re-administered in the spring 2024 semester. All students who participated in this survey were biology majors enrolled in an introductory biology course at the university. All statistical tests and data were analyzed using JASP software (21).

Following the administration of the survey in the fall semester, a total of 310 responses were received. Seven responses were incomplete and were thus removed from the dataset, bringing the final total to 303. Demographics of the fall respondents can be seen in Table 1.

Following the results of the EFA in the fall semester, the survey was re-administered in the spring semester. Due to some questions being deleted following a review of the factor loadings, this version of the survey only contained 56 of the original 76 capital-focused questions. Following administration of the survey, 221 responses were received. Six responses were incomplete and removed, thus bringing the final total to 215. Demographics of the spring respondents can be seen in Table 2. A comparison of demographics between this study and Hiramori (20) can be seen in Table 3.

Exploratory factor analysis

To explore the underlying structure of CCW, we conducted an EFA. A factor analysis allows a researcher to explore the possible underlying structure of a set of variables (22). When employing this approach, a researcher can predict the number of factors to be produced by the analysis based on any prior theoretical basis that is known. Based on the dynamic nature of CCW, we chose to approach this EFA without an expected number of factors. In doing so, we hoped to uncover the sub-dimensions that potentially make up the six forms of capital in the CCW framework. The factoring method used for this EFA was principal axis factoring as this allows the data used to be

TABLE 1 Demographics of survey participants during fall 2023 semester

Group	Sub-group	Participants (*N* = 303)
Gender	Female	225
	Male	72
	Non-binary	5
	Other	0
	Prefer not to say	1
Latin* identity	Latin*	242
	Non-Latin*	61
First-generation status	First generation	122
	Continuing generation	181
LGBTQ + identity	Asexual	2
	Bisexual	23
	Gay	6
	Heterosexual	235
	Pansexual	5
	Queer	6
	Questioning	3
	Other	4
	Prefer not to specify	19

TABLE 2 Demographics of survey participants during spring 2024 semester

Group	Sub-group	Participants (*N* = 215)
Gender	Female	159
	Male	53
	Non-binary	2
	Other	1
	Prefer not to say	0
Latin* identity	Latin*	165
	Non-Latin*	50
First-generation status	First generation	93
	Continuing generation	122
LGBTQ + identity	Asexual	0
	Bisexual	18
	Gay	8
	Heterosexual	163
	Pansexual	0
	Queer	6
	Questioning	4
	Other	0
	Prefer not to specify	14

non-normally distributed (23). Additionally, since the capital found in CCW is recognized to not be fully independent of each other, we chose an oblique (oblimin) rotation to allow for interaction between the variables. Lastly, we selected the cutoff value of 0.40 for factor loadings and deleted items that did not meet that threshold (24, 25). We then reiteratively repeated the process until a final model could be reached. The final model produced from the EFA proposes a 10-factor model, similar to what was identified by Hiramori et al. (20).

TABLE 3 Comparison of demographics between research study and source study

Group	Sub-group	Hiramori (20) participants (*N* = 742)	Participants in this study (*N* = 518)
Gender	Female	431	384
	Male	280	125
	Non-binary	24	7
	Other	3	1
	Transgender	9	-
	Prefer not to say	-[a]	1
Hispanic or Latin* identity		479	407
First-generation status	First generation	-	215
	Continuing generation	-	303
LGBTQ + identity	Asexual	11	2
	Bisexual	89	41
	Gay	23	14
	Heterosexual	554	498
	Pansexual	18	5
	Queer	14	12
	Questioning	13	7
	I do not understand the question	4	-
	Other	9	4
	Prefer not to specify	-	33
Major	Biology	210	518
	Other STEM	384	0
	Non-STEM	43	0
	Other	105	0

[a]-, the respective survey did not include this question when capturing demographics.

FIG 1 Proposed dimensions of community cultural wealth based on exploratory factor analysis.

Confirmatory factor analysis

To further confirm the model produced by the EFA, a CFA was conducted. Since the survey items were ordinal with some responses being non-normally distributed, we utilized diagonally weighted least squares (DWLS) to assess our proposed model (26). When assessing, we referred to multiple fit indices including, χ^2, comparative fit index (CFI), standardized root-mean-square residual (SRMR), and root-mean-square error of approximation (RMSEA). The following model fit cutoffs were used. These are based on traditional recommendations both from Hu & Bentler and others (27, 28):

- $0 \leq \chi^2 \leq 2df$
- $0.95 \leq CFI$
- $0.05 \leq SRMR \leq 0.10$
- $0.05 \leq RMSEA \leq 0.08$

RESULTS

Exploratory factor analysis

The number of students who completed the survey in fall 2023 was 303. This number was seen as acceptable for our study as we surpassed 300 which is commonly used as a "good" recommendation and passes the absolute minimum of 50 (29, 30). The EFA from this study revealed an underlying 10-dimension latent structure similar to the findings of Hiramori (20). These findings reveal that some of the forms of capital have sub-dimensions that may exist to them (Fig. 1). Additionally, Cronbach's Alpha was calculated to determine reliability of the items within each factor. Values of alpha were

considered based on score with $\alpha \geq 0.70$ being acceptable, $\alpha \geq 0.80$ being good, and $\alpha \geq 0.90$ being excellent (31, 32).

The first factor that emerged from our EFA was that of "Familial Heritage and support" (Fig. 2). This factor contains a total of 11 questions from an original set of 18. These questions aimed at measuring different aspects of familial capital which encompasses the support, values, and resources that can be provided by one's family.

The original aspirational capital group contained a total of 14 items, two of which would end up deleted. Seven of the remaining items would be grouped under the dimension of "Future Vision & Encouragement." This dimension pushes individuals to consistently think long-term even when faced with potential barriers. The remaining five questions from this group would become the "External Inspirations" dimension which refers to the acquisition of aspirational capital from others, such as teachers (Fig. 3).

The navigational capital group began with 10 questions, with three being deleted and the remaining seven becoming the "Navigational Mastery" dimension of CCW (Fig. 4). This dimension draws directly from navigational capital that refers to the capital needed to navigate and negotiate certain institutional systems. Many of the skills that fall in this dimension are critical for college success such as time management and taking advantage of resources.

Similar to the navigational and familial groups, the social capital items factored together. This group started with 10 items and would finish with 6 and become the "Networked Support System" dimension (Fig. 5). This dimension acknowledges the benefit that a network of relationships can have on an individual.

While most of the capital questions were either divided into two different factors or stayed as a singular group, the resistant capital group split into three dimensions. Originally there was a set of 14 items, and 12 remained following the EFA. The first dimension is "Social Justice Conviction" which contains five items. This dimension refers to the knowledge and/or awareness of different forms of injustices and a desire for change. The next three resistant capital items were grouped under "Empowerment through Representation" that connects to stereotypes and wanting to be a role model. Lastly, the remaining four items were grouped under "Advocacy for Equity" that seeks to take the next step by making strides toward greater systemic change (Fig. 6).

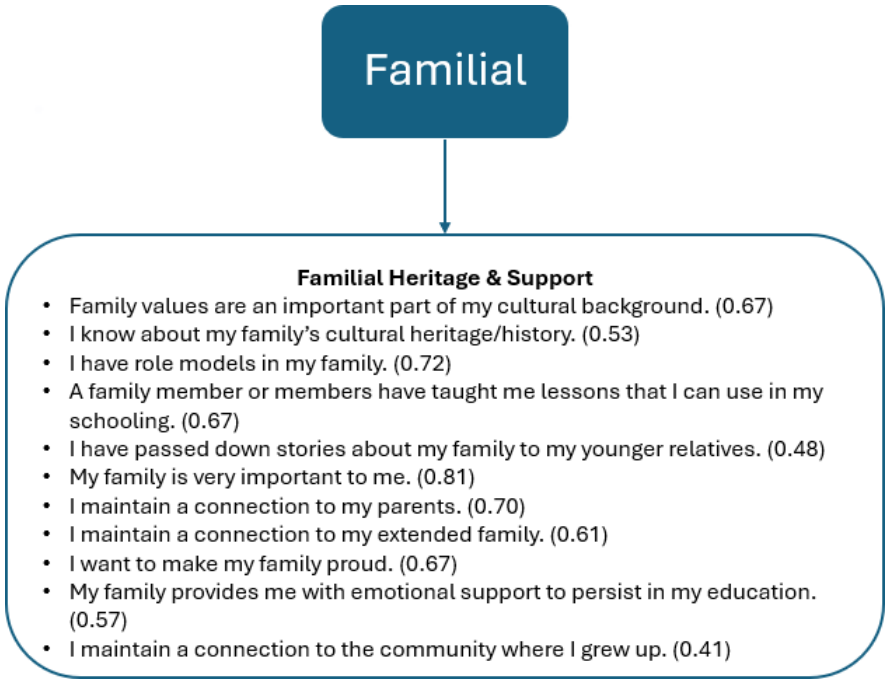

FIG 2 Familial Heritage and Support dimension survey items and factor loadings.

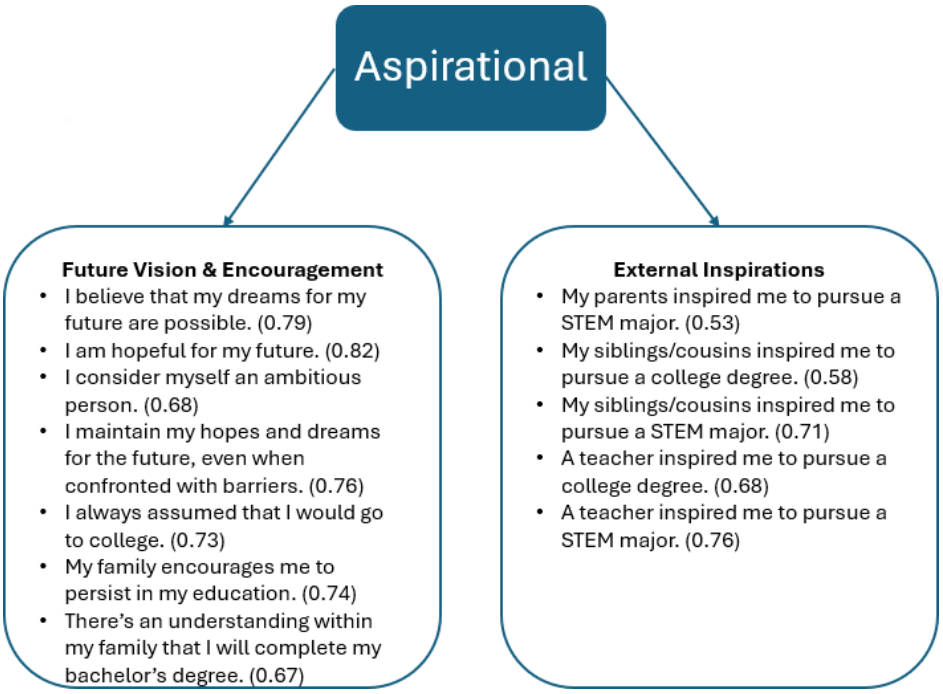

FIG 3 Aspirational capital dimensions with survey items and factor loadings.

Lastly, the final group of questions relates to linguistic capital. This group had originally 10 questions, with two ultimately deleted. Five of the remaining questions were grouped under "Artistic & Creative Expressions." These items aimed to measure the different ways someone may communicate ideas beyond the traditional written word or tongue. The final three questions were grouped under "Adaptable Communication" which refers to the ability to change one's communication approach based on the environment (Fig. 7).

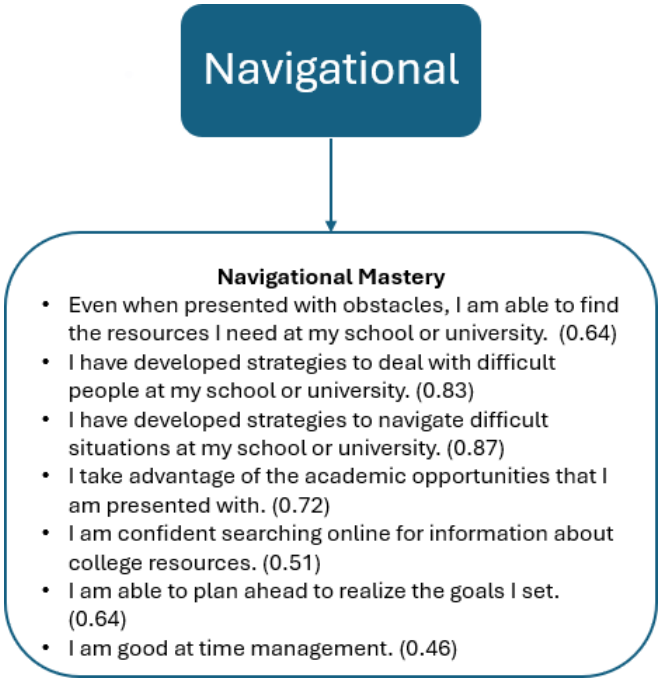

FIG 4 Navigational Mastery dimension survey items and factor loadings.

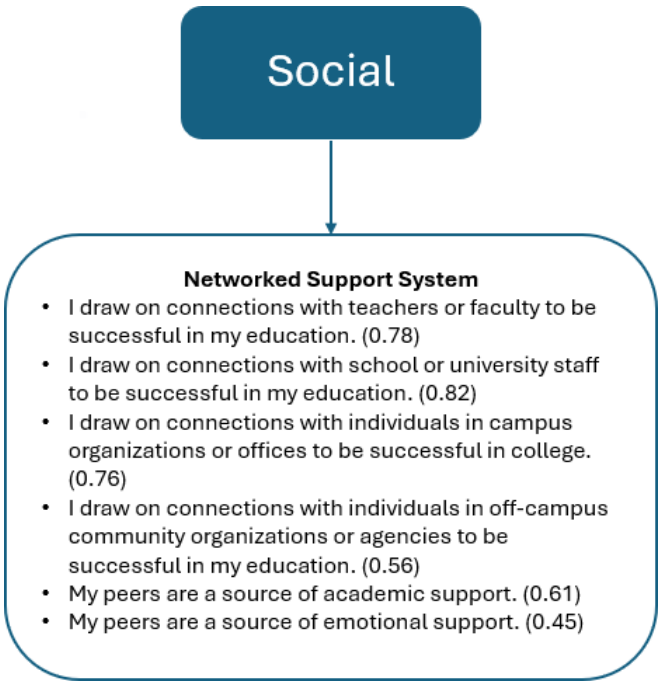

FIG 5 Networked Support System dimension survey items and factor loadings.

While the proposed 10-factor structure is consistent with what was found in Hiramori et al.'s (20) EFA, there were differences in how the items grouped to form each factor. For example, in our EFA, each factor consists of only items aimed at measuring a single capital, such as "Familial Heritage & Support" only containing familial capital questions. Whereas Hiramori et al. (2024)'s study revealed factors that may relate to multiple capitals such as their proposed "Aspirational Navigational" dimension that contained both aspirational and navigational capital items. Ultimately, many of the survey items that were kept in our study following the EFA were also kept in Hiramori et al.'s (20) study even if present in different factors (Table 4).

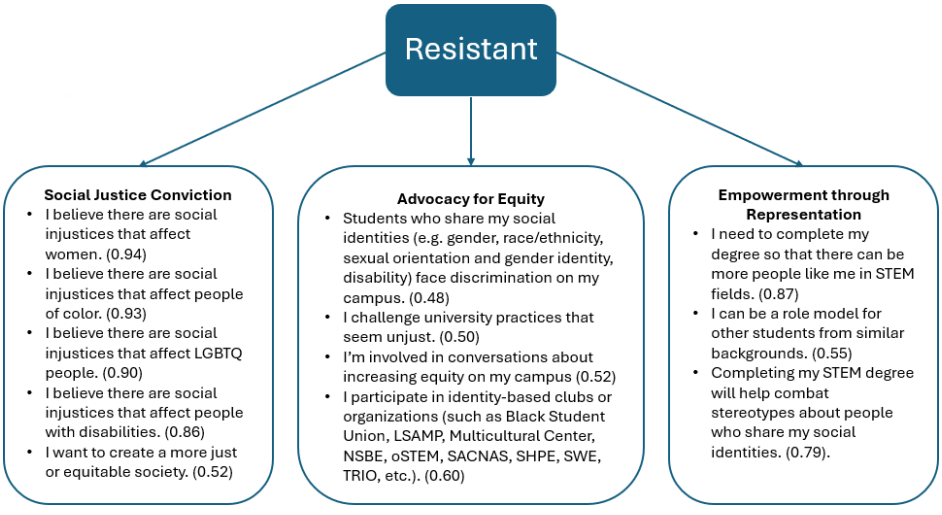

FIG 6 Resistant capital dimensions with survey items and factor loadings.

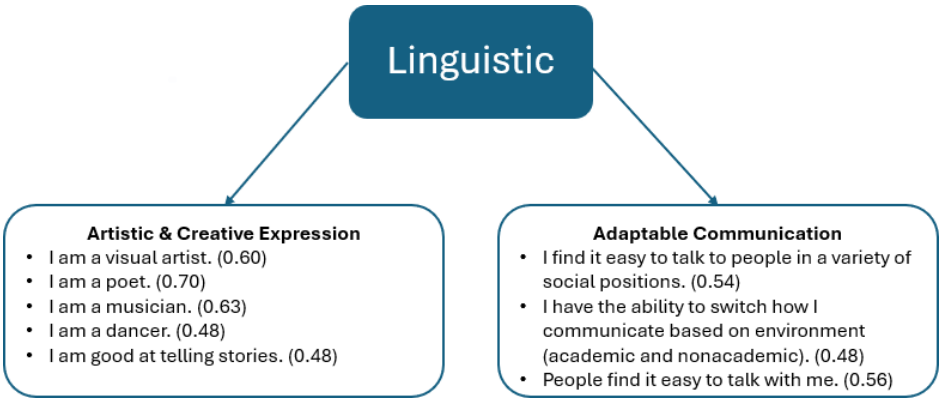

FIG 7 Linguistic capital dimensions with survey items and factor loadings.

Confirmatory factor analysis

The number of students that completed the now shortened 56-question survey in Spring 2024 was 215. While this number was lower than the fall semester, it was still acceptable to perform a CFA (30). Based on the results from the EFA, a 10-factor CFA with all 56 questions was conducted. The chi-square test of model fit was significant ($\chi^2 = 2426.075$, $df = 1439$, $P < 0.001$). Values for SRMR and RMSEA also came up in an acceptable range with 0.086 and 0.057, respectively. The CFI for this model was 0.937 that fell just below the aimed cutoff of 0.95. However, it is important to note that some studies utilize a cutoff of 0.90 for CFI which would support fit in the situation presented here (27, 33). Overall, results from the CFA further validate the instrument adapted from Hiramori (20) as a method of measuring the different dimensions of CCW in populations similar to the one used in this study.

DISCUSSION

Our study sought to explore the underlying factor structure that forms CCW by validating a newly developed instrument that aimed to measure these factors quantitatively. Findings from our exploratory factor analysis EFA revealed a 10-factor structure. The factors identified encompassed various dimensions of CCW including:

- Familial Heritage & Support
- Future Vision & Encouragement
- External Inspirations
- Navigational Mastery
- Networked Support System
- Social Justice Conviction

TABLE 4 Comparison of survey items in the final instrument produced

Original grouping	Total items	Items kept in both final instruments	Items removed in both final instruments	Items kept in our study and removed in Hiramori et al. (20)	Items kept in Hiramori et al. (20) and removed in our study
Aspirational	14	10	0	2	2
Linguistic	10	7	2	1	0
Familial	18	9	5	2	2
Social	10	6	1	0	3
Navigational	10	7	3	0	0
Resistant	14	9	1	3	1
Totals	76	48	12	8	8

- Empowerment through Representation
- Advocacy for Equity
- Artistic & Creative Expression
- Adaptable Communication

These proposed dimensions reflect the diverse assets and experiences that students bring with them in pursuit of an education. While the 10-factor structure mirrors the results from Hiramori et al. (20), there were differences in the items that made up each of the factors. Ultimately, this confirms the suggestions made in prior research that CCW is multifaceted with many distinct dimensions to the 6 forms of capital presented by Yosso (10). Additionally, slight differences in our population may have led to nuances in results. For example, our participants contained a higher proportion of females (74.3%) than Hiramori et al. (20)'s population (58.4%). Our study also contained a slightly higher proportion of Latin* students (79.9%) than the source study (65%). Lastly, our study contained only biology majors whereas their study included other STEM and some non-STEM majors.

In our study, about half of the final survey items were grouped together under the dimension most reflective of the original capital to which they were assigned. For example, all the remaining familial capital questions were grouped under the "Familial Heritage & Support" dimension. In contrast, the remaining survey items that were originally grouped under aspirational capital and linguistic capital were split into two separate dimensions each, and the resistant capital items were split into three separate dimensions.

When it comes to the dimensions of aspirational capital, our study reflects that aspirations can be intrinsically or extrinsically influenced. This is represented by "The Future Vision & Encouragement" and "External Inspirations" dimensions. The first of these focuses on a student's ability to think long-term when referring to their education. For example, this grouping contained questions like "I am hopeful for my future" and "I believe that my dreams for my future are possible." Statements like these create a thought that begins from within the student. Whereas the "External Inspirations" dimension creates feelings or thoughts that begin from someone else such as, "a teacher inspired me to pursue a STEM major" or "My siblings/cousins inspired me to pursue a STEM major." By considering these dimensions of aspirational capital, we can work with students to develop their long-term aspirations while finding additional sources of inspiration and support to keep them going on their journey through STEM.

In Yosso's (2005) original CCW framework, linguistic capital is seen as any abilities or assets honed through communication or expression. Our EFA divided the final linguistic capital items into two dimensions, "Artistic & Creative Expression" and "Adaptable Communication." Between these two dimensions, both verbal and non-verbal methods of expressing ideas are captured, which is at the core of linguistic capital. Understanding the different ways students can express ideas can remind us that there is not one way of showing mastery in our classrooms.

As previously mentioned, the resistant capital group was divided in three ways, "Social Justice Conviction," "Empowerment through Representation," and "Advocacy for Equity." We believe that these dimensions naturally build from one to the next. In other words, it highlights the transition from *knowing* about inequities to *wanting change* and then ultimately, taking an *active* role in advocating for equity. While resistant capital may express itself differently in every student, the core of what matters does not change. We must continue to recognize that inequities exist and not just take a role in dismantling them but empower students to help as well.

Similar to the familial capital questions, the remaining navigational and social capital questions were grouped into their own dimensions named "Navigational Mastery" and "Networked Support System." While we may not have identified additional dimensions to familial, navigational, and social capital, it does not conclude that other dimensions do not exist. Additionally, this could potentially suggest that these forms of capital, as

defined by Yosso (10) and the survey items, may simply be a strong dimension to CCW on its own.

Lastly, based on the 10-factor structure produced by the EFA, we aimed to confirm this model through a CFA. Our results indicate that the model produced is acceptable, which further validates the survey instrument. More specifically, the χ^2, RMSEA, and SRMR values all fell within the desired range. While CFI (0.937) may have fallen short of the 0.95 desired cutoff, it was above 0.90 which has been used as a cutoff in other studies (27). Additionally, this one measure does not automatically disprove the validity of the model produced by the EFA as researchers must also consider the theory behind it (34). As such, since CCW is seen as multifaceted and not a static theory, we argue that the slightly lower CFI value is representative of that. CCW manifests differently across all students, and thus one should expect nuances in any statistical analyses that utilize this framework.

Recommendations and conclusions

Our study further validates the survey instrument developed by Hiramori et al. (20). The variations seen in our final instrument compared to the original could be indicative of nuances that exist between study participants. Our population consisted of all biology majors enrolled in an introductory biology course at a large Hispanic-serving institution. Additionally, we had a slightly higher proportion of students that were of a Latin* background, and the vast majority also identified as female. These differences in demographics and backgrounds could have resulted in slight differences emerging in the underlying factor structure of CCW. Ultimately, we believe that this instrument can be trusted to be utilized in other similar contexts to measure CCW among the student population, especially those with a high Latin* population. As such, we recommend using this instrument and further validating it in other contexts. Additionally, future directions may include the further validation of new questions that measure other potential forms of capital, such as spiritual capital. By continuously building upon this tool, we can ensure that all forms of wealth that help students succeed are highlighted. Ultimately, we hope to better understand the CCW of our students to be able to adapt our approaches to meet their "wealth" and design interventions that take these dimensions into account.

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