Algebra Conceptual Understanding and Predicting STEM Degree Completion

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Algebra has been found to be a barrier to college and STEM-major completion, and a contributing factor to unequal access to STEM fields. Conceptual understanding has often been discussed as an important component of mathematics learning; yet more marginalized students often have less access to rich mathematics instruction and to algebra learning opportunities. However, to date no research has investigated the relationship between conceptual understanding and math or STEM outcomes in college. In this research, we explore the predictive validity of the recently validated Algebra Concept Inventory (ACI) to determine whether college students' ACI scores predict math course grades, STEM-major math course completion, and STEM vs. non-STEM degree attainment as well as whether ACI score explains outcome differences by race/ethnicity/gender.

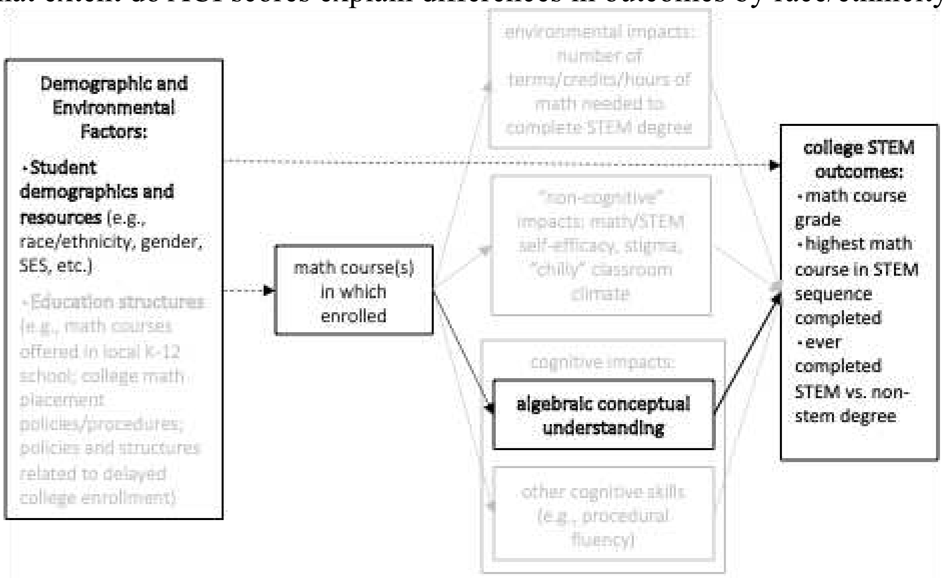
Keywords: Algebra, conceptual understanding, college students, STEM majors, equity

Students' prior mathematical preparation (e.g., Cohen & Kelly, 2020; Minaya, 2021) and their college performance (Chen & Soldner, 2013) influence whether they enroll in or persist in STEM degrees. Algebra serves as both a barrier to college degree completion (e.g., Bailey et al., 2010; Ganga & Mazzariello, 2018) and a requirement for earning a STEM degree (Bahr et al., 2017; Sithole et al., 2017). However, there is no large-scale research on whether algebraic conceptual understanding influences STEM degree completion. Algebraic conceptual understanding may also represent an equity issue, as research indicates that marginalized students have fewer opportunities for rich instructional experiences to develop higher-level skills, such as conceptual understanding (Schoenfeld, 2022; Yeh et al., 2020). Marginalized students are also less likely to enroll in and complete STEM degrees (e.g., Black et al., 2021; Hatfield et al., 2022; Wright et al., 2023).

Prior research on persistence in STEM degrees has explored various predictors, including environmental impacts from course sequences (e.g., Ryu et al., 2022), college math placement policies (e.g., Ngo et al., 2018), and general cognitive skills (Park et al., 2021). Yet, there is limited exploration of whether specific measures of conceptual understanding predict STEM outcomes. Existing models of STEM major retention that do include academic factors tend to use more diffuse assessments of general knowledge, such as GPA or standardized test scores (e.g., Alkhasawneh & Hargraves, 2014; Gipson, 2016; Wolniak, 2016). Additionally, models including specific math course completion as predictors may obscure the separate impact of different factors that are difficult to distinguish because they are correlated with course enrollment and completion (e.g., Crisp et al., 2009; Larnell, 2016; Quarles & Davis, 2017).

Our research is distinguished by a college STEM major retention model that includes algebraic conceptual understanding as a core factor (Figure 1). We use scores on the validated Algebra Concept Inventory (ACI; Wladis et al., 2024a) as a measure of algebraic conceptual understanding to explore the following research questions:

- Can ACI scores predict: a) students' grades in a student's current mathematics course? b) whether they ever completed core math courses required for STEM majors? c) whether they ever completed a STEM vs. non-STEM degree?
- To what extent do ACI scores explain differences in outcomes by race/ethnicity or gender?



Notes: Grey arrows represent relationships that have been tested in other research. Thick black arrow at far right represents main relationship tested in this research. Thin black arrow represents fixed effects by course (controlled for in all analyses). Dotted black arrows represent control variables included in analyses that use controls.

Figure 1. Model of STEM Major Access and Retention as it Relates to College Math Course Placement

Algebraic Conceptual Understanding

Conceptual understanding is crucial in mathematics (Booth, 2011; Richland et al., 2012), though it is frequently neglected in algebra instruction. This is especially important for STEM students, who should be able to flexibly apply their algebraic knowledge in unfamiliar situations (Quarles & Davis, 2017). Access to effective and meaningful mathematics instruction is an equity concern since marginalized students often face fewer chances to develop advanced mathematical skills (e.g., Schoenfeld, 2022), and this access gap may significantly influence STEM degree progression and completion.

Algebraic conceptual understanding as measured by the ACI refers to understanding of mathematical concepts, which is defined as including mathematical reasoning about concepts. In the ACI, concepts are defined as well-defined mathematical processes, objects, or ideas accepted by the mathematical community (Sfard, 1991). The ACI emphasizes algebraic concepts that are accessible to students beginning in elementary algebra such as equivalence, syntactic structure, algebraic properties, functions/variation, and variable.

Below we present an ACI item as an illustrative example:

In the expression $-2x^3 + 5$*, which part is being cubed (or raised to the third power)?*

a. $-2x$
b. $2x$
c. x

Students conceptualizing the normative structure of the syntax of the expression would most likely choose C, the correct answer. Alternatively, students who choose incorrect options A or B typically extract the structure of the syntax from non-mathematically salient features drawn from instructional experiences, like spacing, or how often instructors treat substrings of the form ax for some number a as a unified subexpression during transformation. These students may conceptualize the meaning and structure of algebraic syntax differently than those who link it to normative operational precedence (for more details, see Wladis et al., 2024b, 2024c).

The ACI's 402 multiple-choice items were developed and previously validated through a cyclical process using the Evidence-Centered Assessment Design (ECD) Framework (Mislevy & Riconscente, 2005) (see details in Wladis, et al., 2024a). The ACI is the first large-scale assessment to undergo mixed-methods validation for measuring algebraic conceptual understanding in college students, particularly for students across course levels. It was validated for use with students starting in elementary algebra. In this study we use previously collected ACI scores to explore the relationship between algebraic conceptual understanding and college outcomes such as math course grade, completion of STEM-major math courses, and STEM vs. non-STEM degree completion.

Method

Participants and Data Collection

The participants in this study were students enrolled in mathematics courses at the largest community college in the City University of New York (CUNY) between spring 2019 and summer 2023. The participants were enrolled in a wide range of math courses, from elementary algebra to advanced topics such as calculus, linear algebra, and differential equations. Data obtained from CUNY's Institutional Research (IR) Offices included detailed information on each student's course enrollment and grades, demographic characteristics (e.g., gender and race/ethnicity), academic background (e.g., G.P.A., credits earned, and major), as well as socio-economic status, which was approximated using household income data from the American Community Survey based on students' home zip codes. Institutional records were combined with the existing ACI dataset to explore relationships between students' algebraic conceptual understanding and their academic outcomes.

The ACI dataset included student scores generated during the creation and validation of the ACI. A total of 402 unique items were developed and tested; this study analyzes data from 6,582 students who took the inventory for whom CUNY then also provided additional administrative data. Math courses in which students were enrolled included elementary algebra, intermediate algebra, mathematics for elementary educators I and II, quantitative reasoning, various levels of statistics, mathematics for liberal arts majors, mathematics for health science majors, discrete mathematics, precalculus, Calculus I, II and III, advanced calculus, linear algebra, abstract algebra, and differential equations. For more information on the initial data collection and validation of the ACI see Wladis, et al. (2024a).

Data Analysis

A student's score on the ACI was the primary independent variable of interest. ACI scores are based on multiple test forms designed through common-item random groups equating design, where each student was given a different subset of approximately 25 of the 402 items. Analysis has demonstrated excellent reliability and validity for the inventory (Wladis et al., 2024a). Given its wide coverage of algebra concepts and limited prerequisite knowledge, the ACI is well-suited for investigating whether algebraic conceptual understanding is a predictor of math outcomes and STEM degree progress or attainment for students enrolled in a wide range of math courses.

ACI scores were generated using two-parameter logic (2PL) item-response-theory (IRT) models, which account for differences in item difficulty and discrimination. The models produced scores (θ values) representing how many standard deviations a student's performance was above or below the mean compared to others in the sample. For students who took the ACI more than once in a term (due to multiple math course enrollments), the mean ACI score for that term was used in the analysis.

Dependent variables included in this study are course grade (converted to GPA scale), successful course completion (defined as earning a grade of C or better), and STEM or non-STEM degree attainment during the study period. Control variables included gender, race/ethnicity, age, GPA, credits earned, and median income of home zip code. Missing data were minimal, affecting less than 2% of the dataset, so we used listwise deletion for these cases. We categorized math courses by their relevance to typical STEM major required math course sequences and by prerequisites. Fixed effects were added to account for the specific course taken, and/or course level or sequence.

We primarily employed fixed-effects linear and logistic regression models to predict math course grades and STEM degree attainment. For binary outcomes, both logistic and linear probability models were used, with linear models reported for easier interpretation. For mediation analysis, we used the KHB decomposition method (Kohler et al., 2011), to decompose disparities in ACI scores into "indirect" and "direct" components related to race/ethnicity and gender.

To address differences between the full student population, and students for whom we had ACI scores, we used entropy balancing (Hainmueller, 2012) to reweight data and improve covariate balance. This allowed ACI-taking to be independent of measured background characteristics. This step was important since students who consented to take the ACI may have been more likely to be higher-achieving, with better math self-efficacy and performance. They were more likely to be Asian, female, and slightly older, with fewer credits earned. Despite these differences, we maintained a wide representation of gender, GPA, and racial/ethnic groups. Entropy balancing resulted in a weighted dataset that closely reflected the full population of students enrolled in math courses, ensuring that our analysis would allow for inferences across the general population.

Results and Discussion

One goal of our analysis was to determine if ACI scores would predict course completion and STEM degree attainment. A one standard deviation (SD) increase in ACI score on average correlated with a 0.4 increase in grade points (scale 1-4) in the math course in which a student was enrolled ($p < 0.001$) (Table 1). This was reduced but remained highly significant ($p < 0.001$) in full models with covariates. For individual courses, ACI scores significantly predicted grades in most math classes, especially those that rely heavily on algebra: intermediate/college algebra[1], precalculus, and Calculus I ($p < 0.001$). ACI scores also significantly predicted course completion (if attempted) for each of the five core STEM major mathematics requirements, in base and full models ($\alpha = 0.001$ level for all except full model predicting Calculus II completion, where $\alpha = 0.008$). These differences were not due to correlations between ACI

[1] We were unable to include elementary algebra courses in this analysis due to small *n*; very few had grades beyond pass/fail designations.

score and currently enrolled course level, because all models included fixed effects for course level.

Table 1. ACI Score as Predictor of Math Course Grade, Completion of Core Math Courses for STEM Major, Completion of STEM vs. Non-STEM Major.

As a Predictor of Math Course Grade (Grade Scale: 1-4)								
	Base models				Full models[a]			
Fixed effects by course sequence number, regression results								
	Coefficient	SE	*p*	sig.	Coefficient	SE	*p*	sig.
ACI score	0.40	0.03	0.000	***	0.26	0.02	0.000	***
sequence	0.08	0.03	0.007	**	0.05	0.03	0.066	.
Separate models for each course type, regression results								
Coefficient for ACI score	Coefficient	SE	*p*	sig.	Coefficient	SE	*p*	_
intermediate/college algebra	0.55	0.05	0.000	***	0.40	0.04	0.000	***
precalculus	0.51	0.04	0.000	***	0.36	0.04	0.000	***
Calculus I	0.46	0.09	0.000	***	0.24	0.05	0.000	***
Calculus II	0.28	0.10	0.006	**	0.06	0.11	0.600	
As a Predictor of Successful Completion of Core Math Courses in STEM Major Requirements								
Ever completed:	Coefficient	SE	*p*	sig.	Coefficient	SE	*p*	sig.
elementary algebra	0.16	0.04	0.000	***	0.15	0.05	0.001	**
interm./college algebra	0.14	0.02	0.000	***	0.11	0.02	0.000	***
precalculus	0.13	0.02	0.000	***	0.09	0.02	0.000	***
Calculus I	0.15	0.03	0.000	***	0.09	0.02	0.000	***
Calculus II	0.11	0.02	0.000	***	0.08	0.03	0.008	**
Calculus III	0.05	0.11	0.667		0.01	0.08	0.951	**
differential equations	0.62	0.38	0.105		0.90	0.33	0.006	**
mathematics education	0.38	0.08	0.000	***	0.23	0.06	0.000	***
statistics	0.34	0.05	0.000	***	0.20	0.05	0.000	***
quantitative reasoning	0.35	0.11	0.001	**	0.18	0.09	0.048	*
health	0.35	0.07	0.000	***	0.18	0.07	0.009	**
As Predictor of STEM vs. non-STEM Degree Completion								
ever attained STEM vs. non-STEM degree	Coefficient	SE	*p*	sig.	Coefficient	SE	*p*	sig.
ACI score	0.051	0.012	0.000	***	0.049	0.012	0.000	***
ACI score	0.040	0.013	0.002	**	0.040	0.013	0.002	**
course grade	0.178	0.014	0.000	***	0.188	0.015	0.000	***

Notes: Multi-Level Weighted Regression, fixed effects by course (first row) or separate models by courses (listed in first column), random effects by instructor, math course grade as dependent variable, ACI score as independent variable; *Sig. levels*: *** $\alpha = 0.001$, ** $\alpha = 0.01$, * $\alpha = 0.05$, . $\alpha = 0.10$
[a]Full models include control variables: GPA at start of term, number of prior credits earned by start of term, race/ethnicity, gender, age, and median household income of zip code

We also found that for students who completed a two- or four-year degree during the study period and who were in the same level mathematics course when taking the ACI, that those with higher ACI scores were significantly more likely to graduate with a STEM degree. In fact, the ACI score predicted STEM degree completion more strongly than course grade alone. For every one standard deviation increase in ACI score, students were 5.1 percentage points more likely to complete a STEM degree when accounting for fixed effects for course level. In models with both ACI score and course grade, one standard deviation increase in ACI score and one letter grade increase corresponded to 4.0 and 1.8 percentage point increases in STEM degree completion, respectively; this illustrates the predictive power of ACI scores above and beyond the information provided by course grades.

Another goal of our analysis was to determine the extent to which ACI scores explain differences in outcomes by race/ethnicity and gender. For race/ethnicity, we found direct and indirect discrepancies related to course grades highly significant in both base and full models with controls (Table 2).

Table 2. ACI Score as Mediator Between Underrepresented Minority Status (URM)[a] or Gender and Math Course Grade

	Base models				Full models			
underrepresented minority status	Coef.	SE	*p*	sig.	Coef.	SE	*p*	sig.
total discrepancy (total "effect")	-0.65	0.05	0.000	***	-0.42	0.06	0.000	***
direct discrepancy (direct "effect")	-0.54	0.05	0.000	***	-0.36	0.06	0.000	***
indirect discrepancy (indirect "effect")	-0.11	0.01	0.000	***	-0.06	0.01	0.000	***
female gender	Coef.	SE	*p*	sig.	Coef.	SE	*p*	sig.
total discrepancy (total "effect")	0.24	0.04	0.000	***	0.23	0.05	0.000	***
direct discrepancy (direct "effect")	0.29	0.04	0.000	***	0.26	0.05	0.000	***
indirect discrepancy (indirect "effect")	-0.04	0.01	0.000	***	-0.03	0.01	0.001	**

Notes: Mediation using the KHB Method: Mediation of the Relationship Between Underrepresented Minority Status or Gender and Math Course Grade by ACI Score, fixed-effects by course sequence number, clustering by instructor; *Significance levels*: *** $\alpha = 0.001$, ** $\alpha = 0.01$, * $\alpha = 0.05$, . $\alpha = 0.10$
[a]Underrepresented minority indicates students of color who have been traditionally underrepresented in STEM fields, and includes Black, Hispanic, and American Indian/Native Alaskan students (vs. White and Asian/Pacific Islander students)

In Table 2 we see that ACI score accounts for 17% of the difference in course grades by race/ethnicity in base models and 13% in full models. We also found direct and indirect discrepancies related to STEM-major-math-course-sequence completion highly significant in base and full models (except full models for elementary algebra). ACI scores explain about 16-18% of the difference for intermediate/college algebra through Calculus I in base models and 7-11% in full models. Finally, for race/ethnicity, neither the total nor direct discrepancy related to STEM-vs.-non-STEM-degree completion is significant in base or full models, while the indirect discrepancy is significant. Interestingly, after accounting for the indirect relationship of ACI score as an explanatory variable for differences in STEM vs. non-STEM major attainment by race/ethnicity, underrepresented minorities are ***more*** likely to complete a STEM vs. non-STEM degree (although not statistically significantly so). Thus, ACI score explains 100% of the total discrepancy in STEM vs. non-STEM degree attainment by race/ethnicity.

For gender, exploring mediation models shows different trends for course completion. While both direct and indirect discrepancies are highly significant in base and full models, the direction of the relationship is different. Despite having lower ACI scores, women on average earn higher grades in mathematics courses. Thus, considering a mediation model that includes ACI scores reveals a suppressor "effect" where women earn even higher grades than men with equivalent ACI scores. Looking at STEM-major-math-course-sequence completion, the models suggest a suppressor "effect" (significant for all courses except elementary algebra and Calculus II full models), where women are on average more likely to complete core mathematics course requirements for STEM majors, even though they score on average lower on the ACI. Finally, concerning degree attainment, exploring mediation models for gender shows the total, direct, and indirect discrepancies are all statistically significant, with ACI score explaining about 10% of the total discrepancy in base and full models (or 10% of differences in STEM vs. non-STEM degree attainment by gender).

Implications and Conclusion

This study found that ACI scores predict math course grades, successful completion of core math courses required for STEM majors, and STEM vs. non-STEM degree attainment. Notably, the ACI score was predictive of STEM degree completion even when controlling for course grades, showing a predictive strength comparable to or even stronger than the predictive power of course grades. In particular, a one-standard-deviation increase in ACI score was associated with a one-third to one-half letter grade improvement in courses such as algebra and calculus, an 8-16% increase in the probability of completing core math courses, and a 4-5% increase in STEM degree attainment.

While this study included a broad range of students, we note that those who completed the ACI differed slightly from the overall student population enrolled in math courses. Despite this, there was still strong representation across racial/ethnic groups, genders, GPA bands, and course levels. CUNY, where the study was conducted, is more diverse than the average U.S. college, with higher proportions of racial/ethnic minorities, first-generation students, lower SES students, and those requiring developmental coursework. While the findings may be generalizable to a national student population, CUNY's unique diversity makes it a valuable setting for studying the relationship between algebraic conceptual understanding and college math/STEM outcomes for groups that have been traditionally underrepresented in math and STEM.

These results suggest that algebraic conceptual understanding, as measured by the ACI, plays a crucial role in college math and STEM outcomes. The findings support calls to better integrate algebraic conceptual understanding into K-12 and higher education teaching and curricula. Moreover, the study highlights equity concerns, as ACI scores explained significant portions of racial/ethnic and gender disparities in math course grades, core course completion, and STEM degree attainment. Women, despite having lower ACI scores, were more likely to succeed in math courses, which may be related to other factors like dedicating more time to their studies (Wladis et al., 2021; 2024d; 2024e).

This research provides evidence that race/ethnicity and gender differences in access to high-quality K-12 math instruction likely contribute to disparities in STEM outcomes. Future research should investigate how improving algebraic conceptual understanding may enhance college math performance and STEM degree attainment, particularly for groups that have been traditionally marginalized and underrepresented in math/STEM. This study provides some of the first large-scale quantitative evidence linking algebraic conceptual understanding to STEM success, showing the need for targeted interventions to improve math outcomes and equity in STEM.

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References

Alkhasawneh, R., & Hargraves, R. H. (2014). Developing a hybrid model to predict student first year retention in STEM disciplines using machine learning techniques. *Journal of STEM Education: Innovations and Research*, *15*(3). https://www.jstem.org/jstem/index.php/JSTEM/article/download/1805/1627

Bahr, P. R., Jackson, G., McNaughtan, J., Oster, M., & Gross, J. (2017). Unrealized Potential: Community College Pathways to STEM Baccalaureate Degrees. *The Journal of Higher Education*, *88*(3), 430–478. https://doi.org/10.1080/00221546.2016.1257313

Bailey, T., Jeong, D. W., & Cho, S. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics Of Education Review*, *29*(2), 255–270. https://doi.org/10.1016/j.econedurev.2009.09.002

Black, S. E., Muller, C., Spitz-Oener, A., He, Z., Hung, K., & Warren, J. R. (2021). The importance of STEM: High school knowledge, skills and occupations in an era of growing inequality. *Research Policy*, *50*(7), 104249. https://doi.org/10.1016/j.respol.2021.104249

Booth, J. (2011). Why can't students get the concept of math? *Perspectives on Language and Literacy*, *37*, 31–35.

Cohen, R., & Kelly, A. M. (2020). Mathematics as a factor in community college STEM performance, persistence, and degree attainment. *Journal of Research in Science Teaching*, *57*(2), 279–307.

Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. *American Educational Research Journal*, *46*(4), 924–942. https://doi.org/10.3102/0002831209349460

Ganga, E., & Mazzariello, A. (2018). *Math Pathways: Expanding Options for Success in College Math*. Education Commission of the States. https://eric.ed.gov/?id=ED590584

Gipson, J. (2016). Predicting academic success for students of color within STEM majors. *Journal for Multicultural Education*, *10*(2), 124–134. https://doi.org/10.1108/JME-12-2015-0044

Hainmueller, J. (2012). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis*, *20*(1), 25–46.

Hatfield, N., Brown, N., & Topaz, C. M. (2022). Do introductory courses disproportionately drive minoritized students out of STEM pathways? *PNAS Nexus*, *1*(4), pgac167. https://doi.org/10.1093/pnasnexus/pgac167

Kohler, U., Karlson, K. B., & Holm, A. (2011). Comparing coefficients of nested nonlinear probability models. *Stata Journal*, *11*(3), 420–438.

Larnell, G. V. (2016). More than just skill: Examining mathematics identities, racialized narratives, and remediation among black undergraduates. *Journal for Research in Mathematics Education*, *47*(3), 233–269.

Minaya, V. (2021). *Can Dual Enrollment Algebra Reduce Racial/Ethnic Gaps in Early STEM Outcomes? Evidence From Florida*. https://doi.org/10.7916/d8-gven-xq29

Mislevy, R. J., & Riconscente, M. M. (2005). *Evidence-centered assessment design: Layers, structures, and terminology* (9; Principled Assessment Designs for Inquiry (PADI)). SRI International. https://padi.sri.com/downloads/TR9_ECD.pdf

Ngo, F., Chi, W. E., & Park, E. S. Y. (2018). Mathematics Course Placement Using Holistic Measures: Possibilities for Community College Students. *Teachers College Record: The*

Voice of Scholarship in Education, *120*(2), 1–42. https://doi.org/10.1177/016146811812000205
Park, E. S., Ngo, F., & Melguizo, T. (2021). The Role of Math Misalignment in the Community College STEM Pathway. *Research in Higher Education*, *62*(4), 403–447. https://doi.org/10.1007/s11162-020-09602-y
Quarles, C. L., & Davis, M. (2017). Is learning in developmental math associated with community college outcomes? *Community College Review*, *45*(1), 33–51. https://doi.org/10.1177/0091552116673711
Richland, L. E., Stigler, J. W., & Holyoak, K. J. (2012). Teaching the conceptual structure of mathematics. *Educational Psychologist*, *47*(3), 189–203. https://doi.org/10.1080/00461520.2012.667065
Ryu, W., Schudde, L., & Pack, K. (2022). Constructing Corequisites: How Community Colleges Structure Corequisite Math Coursework and the Implications for Student Success. *AERA Open*, *8*, 23328584221086664. https://doi.org/10.1177/23328584221086664
Schoenfeld, A. H. (2022). Why Are Learning and Teaching Mathematics So Difficult? In M. Danesi (Ed.), *Handbook of Cognitive Mathematics* (pp. 1–35). Springer International Publishing. https://doi.org/10.1007/978-3-030-44982-7_10-1
Sfard, A. (1991). On the dual nature of mathematical conceptions. *Educational Studies in Mathematics*, *22*, 1–36. https://doi.org/10.1007/BF00302715
Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. *Higher Education Studies*, *7*(1), 46. https://doi.org/10.5539/hes.v7n1p46
Wolniak, G. C. (2016). Examining STEM Bachelor's Degree Completion for Students With Differing Propensities at College Entry. *Journal of College Student Retention: Research, Theory & Practice*, *18*(3), 287–309. https://doi.org/10.1177/1521025115622782
Wladis, C., Hachey, A. C., & Conway, K. (2024d). It's about time: The inequitable distribution of time as a resource for college, by gender and race/ethnicity. *Research in Higher Education*, 1–33. https://doi.org/10.1007/s11162-024-09796-5
Wladis, C., Hachey, A. C., & Conway, K. M. (2024e). It's About Time, Part II: Does Time Poverty Contribute to Inequitable College Outcomes by Gender and Race/Ethnicity? *AERA Open*, *10*, 1–20. https://doi.org/10.1177/23328584241237971
Wladis, C., Hachey, A.C., Conway, K.M., & Manly, C.A. (2021). *Time as a resource for college: Hidden inequities by gender and race/ethnicity.* Association for the Study of Higher Education (ASHE) Annual Conference, San Juan, Puerto Rico. https://www.ashe.ws//Files/Past%20Conferences/ASHE%202021%20Program%20Book.pdf
Wladis, C., Offenholley, K., Sencindiver, B., Myszkowski, N., & Aly, G. D. (2024a). The Algebra Concept Inventory: Creation and Validation with Students Across a Range of Math Courses in College. In S. Cook, B. Katz, & D. Moore-Russo (Eds.), *Proceedings of the 26th Annual Conference on Research in Undergraduate Mathematics Education* (RUME) (pp. 431–440).
Wladis, C., Offenholley, K., Sencindiver, B., Myszkowski, N., & Aly, G. D. (2024b). *Creation and validation of the Algebra Concept Inventory.* Manuscript under review, Journal for Research in Mathematics Education.
Wright, B., Gunther, O., & Bitar, J. (2023). Why STEM Equity Must Address the Experiences of Women of Color. *The Education Trust*. https://edtrust.org/resource/why-stem-equity-must-

address-the-experiences-of-women-of-color/
Yeh, C., Ellis, M., & Mahmood, D. (2020). From the margin to the center: A framework for rehumanizing mathematics education for students with dis/abilities. *The Journal of Mathematical Behavior*, *58*, 100758. https://doi.org/10.1016/j.jmathb.2020.100758