"Hey, I am doing it!" Developing the Mathematics Identity of Latin* Students in a Specifications Grading Calculus Course

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Calculus courses should embrace innovative pedagogies that promote Latin students' mathematics identity development. One such pedagogy is specifications grading, which might foster students' growth-mindset and perseverance in mathematics. In this study, we examine the mathematics identity development of two Latin* students' in Calculus courses with specifications grading, and we compare this development to that of a student not enrolled in a specifications grading course. We compare the changes in the students' mathematical competence and the changes in their sense of recognition as a doer of mathematics. We discuss how aspects of the specifications grading pedagogy can contribute to students' mathematics identity development.*

Keywords: Alternative Grading, Specifications Grading, Mathematics Identity, Calculus

For many, mathematics is a formidable academic challenge, especially at the college level (Roska et al., 2009; Weisburst et al., 2017). Indeed, despite recent significant gains in Latin* students pursuing mathematically-oriented degrees (Crisp & Nora, 2012), still remaining is a significant underperformance of Latin* students in entry-level mathematics college courses (Otero et al., 2007; Solórzano et al., 2013; Sparks & Malkus, 2013). Even though Latin* students have the capability of succeeding in college-level mathematics (Cole & Espinoza, 2008; Crisp & Nora, 2010), the mathematical under-preparedness experienced by many Latin* college students has even led researchers to designate Calculus as a *gatekeeper course* (Norton et al., 2017; Pyzdrowski et al., 2013; Suresh, 2006), or a course that (un)intentionally impede many Latin* and other underserved students from pursuing mathematically-oriented degrees and careers (Convertino et al., 2022). Despite these hindrances, however, research has demonstrated that fostering mathematics educational spaces in which students develop a stronger sense of self, or *mathematics identity*, significantly impacts their mathematics perseverance and success (e.g., Authors, in press; Matthews, 2020; Miller-Cotto et al., 2020; Morales & DiNapoli, 2018).

To contribute to the ongoing efforts for more equitable educational experiences for undergraduate Latin* students, especially in gatekeeper mathematics courses, we must shy away from pedagogies that rely on archaic dispositions about how people learn. Instead, we must opt for pedagogies that foster stronger mathematical identities by adopting an asset-based orientation towards all learners, including Latin* students. For that reason, we report our pilot efforts in implementing *specifications grading* Calculus I courses in Spring 2022, a pedagogy based on the idea of viewing learning as a process achievable by everyone rather than a result obtained only by a few (Nilson, 2015). This study was guided as follows:

1. How does the mathematics identity development of Latin* students enrolled in a specifications grading Calculus I course compare to the mathematics identity development of Latin* students enrolled in a non-specifications grading course?
2. What aspects of specifications grading foster students' mathematics identity development?

Literature Review and Theoretical Background

Mathematics Identity and its Constructs

Adams (2018) gives a clear definition of *mathematics identity* as "the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the context of our lives" (p. 121). Furthermore, Cribbs et al. (2015) offer an explanatory model for mathematics identity by focusing on students' self-perceptions in three constructs, namely mathematics interest (i.e., how a student perceives their interest in mathematics), recognition (i.e., how a student perceives their external recognition, or lack thereof, as mathematics doers), and competence/performance (i.e., how students perceive their comprehension and performance of mathematics). As shared by Cribs and colleagues (2015), self-perceptions about these three constructs significantly informs students' mathematics identity, and this has the capacity to influence students' goals and participation in mathematics, including the degree of choosing, or not, their future careers in STEM. Therefore, it is crucial for educators to understand and empower students' mathematics identity, especially among marginalized student populations, and let that guide their classroom interactions and practices so that students' self-perceptions in relation to mathematics can be positively impacted (Boaler & Greeno, 2000; Cribbs, et al., 2015).

Specifications Grading

We argue that specifications grading as a pedagogical framework provides us with an educational space that can foster stronger mathematical identities. For instance, instead of awarding points for assessments, students are given specifications on assignments, or learning objectives, and these are assessed via a more asset-oriented process that measures progress rather than correctness. Students are also provided with ample opportunities to revise their work based on instructor feedback and resubmit it until they meet the learning objective at a satisfactory level. In other words, specifications grading adopts a growth-mindset orientation towards learners, believing that all learners have the capacity to overcome setbacks in their learning trajectories. As a result, specifications grading has been shown to provide students with a sense of agency as they obtain a greater control over their mathematical trajectories, not to mention with a more authentic and equitable reflection of their proficiency in their respective courses (Boesdorfer, et al., 2018; Katzman et al., 2021; Stange, 2016; Talbert, 2017; Tsoi et al., 2019). Empirical research in this regard, however, remains scarce (Beatty, 2013; Post, 2017; Toledo & Dubas, 2017;). The gap is even more notorious when we consider the positive impact that a specifications grading pedagogy can have on Latin* students' mathematical identity development. For that reason, we aimed to explore the effects that a specifications grading-Calculus I course could have on Latin* students' mathematical identities.

Methods

We collected data at a Hispanic-Serving Institution in the southwest. In Spring 2022, our institution had 14 sections of Calculus I with approximately 500 students. We implemented the specifications grading course design to 9 sections with approximately 300 students. We divided the content of the course into 29 learning objectives that were assessed throughout the semester. Our assessments consisted of group worksheets, exams, and online homework. The mastery of

every learning objective was tested on both a worksheet and an exam. If a student failed to show mastery of a learning objective on a worksheet on the initial submission, we allowed the student to resubmit. If a student failed to show mastery of a learning objective on an exam, the student was provided with opportunities to retest. Retesting sessions were available weekly after the first exam until the end of the semester. In our traditionally-graded Calculus I sections, a student's grade was based on quizzes, group work, exams, and homework with no opportunities for re-assessments. All 14 sections were expected to teach the same content.

To compare the mathematics identities among our Latin* students, we adapted Cribbs et al.'s (2015) well-established, 12-item mathematics identity survey instrument. Following a 5-point Likert-scale, it not only quantifies the mathematics identity of an individual, but also the three subconstructs of mathematics identity: self-perceived interest, recognition, and competence/ performance in mathematics). Additionally, all individual scores were scaled between one (1) and (5) to facilitate its comparisons within and across students. This meant that each student who took the survey had four different scores representing each construct, all within a 1 – 5 scale. The surveys were given during the second week of classes and on the third-to-the-last week of classes, respectively. In all, the survey was taken by 218, mostly Latin*, students enrolled in Calculus I. Out of the total, 119 enrolled in one of the 9 courses that were implementing specifications grading. These students were mostly 1st generation college students pursuing an Engineering, Biology, or health professional-related major.

Eight survey participants volunteered to participate in an individual follow-up interview. We focus on three of these participants for this preliminary report. To exemplify the most diverse types of cases studies, a common methodology in case study research design (Seawright & Gerring, 2008), we selected three cases of Latin* students, Katie, Oscar, and Carlos (pseudonyms) who demonstrated low to mid-range mathematics identity scores in the pre-survey. Katie and Oscar were enrolled in a Calculus I course using specifications grading, while Carlos was enrolled in a Calculus I course without specifications grading. Individual semi-structured interviews (Bernard, 1988) were conducted virtually with each of the three participants. The interview protocol was designed according to the components of Cribbs et al.'s (2015) model for mathematics identity. Follow-up questions were asked as needed for clarification and elaboration. These interviews were recorded and transcribed.

We analyzed the interview transcripts by using inductive coding (Miles et al., 2013) to classify the themes present in the participants' interview responses. We performed axial coding to organize our codes according to the constructs of interest, competence, and recognition. We then considered the results of the overall survey responses to inform our decision regarding the focus of further qualitative analysis. In doing so, we found that students in classes with specifications grading had higher scores on competence/performance and recognition than those not enrolled in such courses. Therefore, we chose to focus our qualitative analysis on the three students' perceptions of their competence/ performance and recognition in doing mathematics.

Results

Spider-web charts of the participants' mathematics identity scores measured on the surveys are in Figure 1, with mathematics identity, competence/performance, interest, and recognition scores plotted on each of the four axes. The grey region on the charts represents the students' pre-survey scores and the teal region the post-survey scores. These charts illustrate the change in Katie's, Oscar's, and Carlos's scores on the pre- and post-surveys. Katie and Oscar, who participated in a specifications grading course, both demonstrated large increases of one to three

points in every measured score of mathematics identity and its subcomponents. Carlos, who did not participate in specifications grading, had small increases in his mathematics identity, competence, and interest scores, but his recognition score did not change. In what follows, we discuss the results from the qualitative analysis of participant's interview responses, focusing on their perceptions of their competence and recognition in being a doer of mathematics.

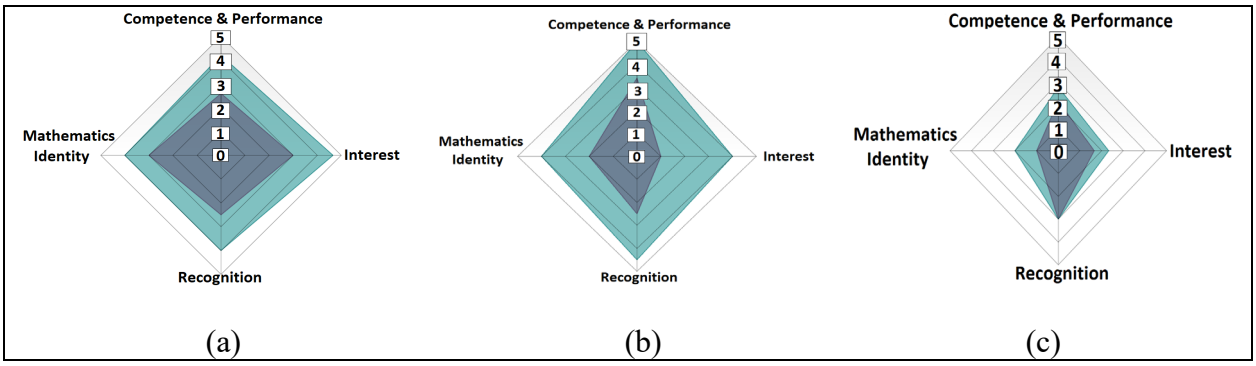

Figure 1. Spider charts demonstrating changes in Katie's (a), *Oscar's* (b), *and Carlos's* (c) *pre- and post-survey scores on measures of mathematics identity, competence, interest, and recognition.*

Students' Competence/Performance in Doing Mathematics

Katie and Oscar reported struggling in their prior mathematics courses: "I [Katie] had an overwhelming plate on my workload, and so I would either fall behind or just keep struggling with that part of the work. I kinda felt alone, I guess, back then… I had to drop the class." Similarly, Oscar referenced his prior Calculus course experience as "a dooming failure," sharing the negative feelings that failing had on him,

> "You're just like, 'Well I'm never going to finish. This is not working,' and you know, all those red X's and stuff like that, it's just puts you down man. It puts you down. You're like 'No I don't want to do this anymore. It's not worth it.'"

In all, they reported feeling overwhelmed and unmotivated to "deal with" their failures. Furthermore, Oscar referred to traditional grading as "either you pass or you don't pass," highlighting how traditional grading acts as gatekeepers for many.

Once in the specifications grading Calculus I course, however, Katie and Oscar demonstrated higher confidence in their competence in doing mathematics in their post-course-survey scores and during the interviews. As shared by Katie, "I am confident with myself…I know what not to do and what I'm capable of doing on my own." Oscar also described his change in confidence as, "You know I thought…I'm never going to pass Calculus. Yes, you can. You can pass it if we put hard work and dedication to it. It is reachable." To this, Oscar attributed his change in confidence to seeing his progression of passed learning objectives: "You start seeing that you're making progress. That motivates you, and that amplifies your performance and gives you more confidence…it gives me confidence like 'Hey, I'm doing it!'…It's a boost to your confidence in your performance to do math." Carlos, on the other hand, self-reported a decrease in his confidence from high school to his traditionally-graded Calculus I: "I'm doing these college courses, and they're more difficult, and there's not that much time… I'm struggling more to really grasp at it… specifically in math where I've been struggling the most."

Overall, Katie and Oscar, who were in a specifications grading course, demonstrated increased confidence in their competence in doing mathematics. Oscar, for example, attributed this change to aspects of specifications grading. On the other hand, Carlos, who was not in a

specifications grading course, self-reported a decrease in confidence, which he attributed to his struggle with the fast-paced Calculus course that moved on to the next topic before he grasped the prior one.

Students' Recognition as a Math Person

Katie and Oscar both increased their measured recognition scores between the pre- and the post-survey, while Carlos showed no change in his recognition score. In the interviews, we further investigated their perceptions of whether their family, friends, and mathematics instructors recognized them as a math person. All three participants claimed that their friends and family recognized them as a math person, and they gave anecdotal evidence about helping their friends with doing mathematics problems. Carlos expressed frustration that his family and friends "definitely" perceived him as a math person: "It's frustrating because… I know that I'm *not* that much. But unfortunately, they keep this illusion, and I'm forced to be pushed down this path that they think I am on, but I'm not." Carlos did not perceive himself as a math person and was frustrated that others did because he thought he could not meet their expectations.

After taking the course with specifications grading, Katie and Oscar reported that their instructors recognized them as a math person. Katie explained, "I think [my instructor] gives me praise for things I do correct and asks me if I'm getting it correct, so I think she does." She referenced the feedback she obtained from the instructor, which is part of the specifications grading process that informs students' revisions. The instructor's positive feedback seemed to give Katie a sense of the instructor's recognition of her as a math person. Carlos, who was not enrolled in a specifications grading course, reported that his instructor saw him as a math person "no more than anyone else." This interview response aligns with Carlos's low score for recognition from the survey. Overall, Katie and Oscar reported that their instructors recognized them as a math person, but Carlos did not. The use of instructor feedback in specifications grading may allow students to perceive their instructor's recognition of them as a competent doer of mathematics.

Discussion

Implementing innovative pedagogies, such as specifications grading, has the potential to foster students' mathematics identity development. Specifications grading realizes this by adopting a growth-mindset that provides students with multiple opportunities to meet their mathematics learning objectives. However, preliminary evidence suggests that specifications grading may also provide Latin* students with educational spaces that may take advantage of Latin* students' *cultural wealth* (Yosso, 2005), or the idea that Students of Color possess a plethora of capital that, when channeled into their education, can serve as critical factors that contribute to students' success in STEM (Samuelson & Litzler, 2016). Because of this, future studies should also explore to what extend do Latin* students' *aspirational capital* (Yosso, 2005), or their ability to maintain hopes and dreams for the future despite the challenges faced as marginalized populations, may be catapulted when they are provided with low-stakes educational spaces in which they feel more in control of their academic trajectories. Furthermore, their *navigational capital,* or their abilities to traverse White-dominated social constructs, like traditional Calculus curricula, could allow them to traverse their specifications grading Calculus I course with more ease given that the learning space values *persistence*, yet another critical characteristic of many Students of Color. Combined, these two forms of capital could also have the capacity to bolster Latin* students' success in Calculus and STEM in general; however,

further studies are necessary. We propose the following discussion question for the audience: What further analyses can help us explore the connection between specifications grading and Latin* students' mathematics identity development? Also, it seems that specifications grading may also take advantage of Latin* students' cultural wealth. If so, what specific characteristics of specifications grading accomplishes this?

References

Adams, M. (2018). I can solve all the problems: LatinX students (re)write their math stories. In I. Goffney, R. Gutiérrez, & M. Boston (Eds.), *Rehumanizing Mathematics for Black, Indigenous, and LatinX students* (pp. 121-134). The National Council of Teachers of Mathematics.

Authors. (in press). [Title omitted for blind review]. Unpublished manuscript.

Beatty, I. D. (2013). Standards-based grading in introductory university physics. *Journal of the Scholarship of Teaching and Learning*, *13*(2), 1−22.

Boaler, J., & Greeno, J. G. (2000). Identity, agency, and knowing in mathematical worlds. In Boaler, J. (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 171-200). Westport, CT: Ablex Publishing.

Boesdorfer, S.B., Galdwin, E., and Lieberum, K. (2018). Emphasizing learning: Using standards-based grading in a large nonmajors' general chemistry survey course. *Journal of Chemical Education*, *95*. DOI: 10.1021/acs.jchemed.8b00251

Cole, D., & Espinoza, A. (2008). Examining the academic success of Latino students in Science Technology Engineering and Mathematics (STEM) majors. *Journal of College Student Development*, *49*, 285-300. doi:10.1353/csd.0.0018

Convertino, C., Alvidrez, M., Pickett, J., & Camberos, D. (2022). Exploring worksheets and attendance-taking as gatekeeping features in a gateway course for Latinx STEM majors. *Journal of Latinos and Education*, 1−17.

Cribbs, J. D., Hazari, Z., Sonnert, G., & Sadler, P.M. (2015). Establishing an explanatory model for mathematics identity. *Child Development, 86*(4),1048−1062. doi: 10.1111/cdev.12363

Crisp, G., & Nora, A. (2010). Hispanic student success: Factors influencing the persistence and transfer decisions of Latino community college students enrolled in developmental education. *Research in Higher Education*, *51*, 175-194. doi:10.1007/s11162-009-9151-x

Crisp, G., & Nora, A. (2012). *Overview of Hispanics in Science, Mathematics, Engineering and Technology (STEM): K-16 representation, preparation and participation* [White paper].

Frenzel, A. C., Goetz, T., Pekrun, R., & Watt, H. M. G. (2010). Development of mathematics interest in adolescence: Influences of gender, family, and school context. *Journal of Research on Adolescence, 20*(2), 507−537. https://doi.org/10.1111/j.1532-7795.2010.00645.x

Gonzalez, L., Lucas, N., & Battle, J. (2022). A quantitative study of mathematics identity and achievement among LatinX secondary school students. *Journal of Latinos and Education*, 1−16. https://doi.org/10.1080/15348431.2022.2073231

Gutiérrez, R. (2018). When mathematics teacher educators come under attack. *Mathematics Teacher Educator*, *6*(2), 68–74. http://www.jstor.org/stable/

Katzman, S.D, Hurst-Kennedy, J., Barrera, A., Talley, J., Javazon, El, Diaz, M., & Anzovino, M.E. (2021). The Effect of specifications grading on students' learning and attitudes in an undergraduate-level cell biology course. *Journal of Microbiology & Biology Education*, *22*(3). http://doi.org/10.1128/jmbe.00200-21

Matthews, J. S. (2020). Formative learning experiences of urban mathematics teachers' and their role in classroom care practices and student belonging. *Urban Education*, *55*(4), 507−541.
Miller-Cotto, D., & Lewis Jr., N. (2020). Am I a "math person"? How classroom cultures shape math identity among Black and Latinx students. https://doi.org/10.31219/osf.io/hcqst
Morales, H., & DiNapoli, J. (2018). Latinx bilingual students' perseverance on a mathematical task: A rehumanizing perspective. *Journal of Research in Mathematics Education*, *7*(3), 226−250.
Nilson, L.B. (2015). *Specifications grading: Restoring rigor, motivating students, and saving faculty time*. Sterling, Virginia: Stylus.
Nilson, L.B. (2016, January 19). *Yes, Virginia, there's a better way to grade*. Inside Higher Ed. https://www.insidehighered.com/views/2016/01/19/new-ways-grade-more-effectively-essay.
Norton, P. R., High, K. A., & Bridges, W. (2017). Calculus I course policy changes and impact on various demographic student group success. In *2017 ASEE Annual Conference & Exposition*.
Otero, R., Rivas, O., & Rivera, R. (2007). Predicting persistence of Hispanic students in their 1st year of college. *Journal of Hispanic Higher Education*, *6*, 163−173. http://doi:10.1177/1538192706298993
Post, S. L. (2017). Standards-based grading in a thermodynamics course. *International Journal of Engineering Pedagogy, 7*(1), 173−181. DOI: https://doi.org/10.3991/ijep.v7i1.6472
Pyzdrowski, L. J., Sun, Y., Curtis, R., Miller, D., Winn, G., & Hensel, R. A. M. (2013). Readiness and attitudes as indicators for success in college calculus. *International Journal of Science and Mathematics Education*, *11*(3), 529–554.
Roksa, J., Jenkins, D., Jaggars, S. S., Zeidenberg, M., & Cho, S. W. (2009). Strategies for promoting gatekeeper course success among students needing remediation: Research report for the Virginia community college system. *Community College Research Center,* Columbia University.
Seawright, J., & Gerring, J. (2008). The case for selecting cases that are deviant or extreme on the independent variable. *Sociological Methods & Research*, *45*(3), 493-525.
Solórzano, D., Acevedo-Gil, N., & Santos, R. E. (2013). *Latina/o community college students: Understanding the barriers of developmental education* (Policy Report No. 10). Pathways to Postsecondary Success. http://pathways.gseis.ucla.edu/publications/DevEdPolicyBrief.pdf
Sparks, D., & Malkus, N. (2013, January). *Statistics in brief: First-year undergraduate remedial coursetaking: 1999-2000, 2003-04, 2007-08* (NCES 2013-013). National Center for Education Statistics. http://nces.ed.gov/pubs2013/2013013.pdf
Stange, K. E. (2016, August) Standards based grading in a first proofs course. University of Colorado. http://math.colorado.edu/~kstange/papers/Stange-standards-discrete.pdf .
Suresh, R. (2006). The relationship between barrier courses and persistence in engineering. *Journal of College Student Retention: Research, Theory and Practice*, *8*(2), 215–239. http://doi.org/10.2190/3QTU-6EEL-HQHF-XYF0
Talbert, R. (2017). *Specifications grading: We may have a winner. RTalbert.org*, https://rtalbert.org/specs-grading-iteration-winner/.
Toledo, S.; Dubas, J. M. (2017) A learner-centered grading method focused on reaching proficiency with course learning outcomes. *Journal of Chemical Education*, *94*(8), 1043−1050.
Tsoi, M. Y., Anzovino, M. E., Erickson, A. H. L., Forringer, E. R., Henary, E., Lively, A., Morton, M. S., Perell-Gerson, K., Perrine, S., Villanueva, O., Whitney, M., & Woodbridge,

C. M. (2019). Variations in implementation of specifications grading in STEM courses. *Georgia Journal of Science*, *77*(2). https://digitalcommons.gaacademy.org/gjs/vol77/iss2/10

Weisburst, E., Daugherty, L., Miller, T., Martorell, P., & Cossairt, J. (2017). Innovative pathways through developmental education and postsecondary success: An examination of developmental math interventions across Texas. *The Journal of Higher Education*, *88*(2), 183−209.