Community College Review
2017, Vol. 45(2) 99–118

DOI: 10.1177/0091552116682829
journals.sagepub.com/home/crw

Math Requirement Fulfillment and Educational Success of Community College Students: A Matter of When

Xueli Wang[1], Yan Wang[2], Kelly Wickersham[1], Ning Sun[1], and Hsun-yu Chan[3]

Abstract

Objective: In community colleges, achieving competence in math is critical to students' timely progression through coursework and eventual educational success; yet, it remains unclear when the optimal timing to complete required math courses is in order to maximize the chance of completing a credential on time. This study examines the timing of college-level math requirement fulfillment in relation to the longer term success of community college students. **Method:** Utilizing survey data and transcript records of 320 students from an urban community college, we performed a survival analysis to investigate how the precise academic terms in which students complete math requirements, taking into account other student behaviors, are related to credential completion. **Results:** Findings reveal that completing math requirements at earlier (e.g., first semester) or later (e.g., fourth or fifth semester) stages of college is related to a higher rate of credential completion. Students who engage in active learning, find academics challenging, and feel academically supported have a higher probability of completing a credential, whereas student-faculty interactions are negatively related to credential completion. **Contributions:** Our findings reveal that fulfilling college-level math requirements early on promises higher odds of credential completion. However, this momentum can be achieved by completing math requirements in Term 1, or it can also be delayed until Terms 4 or 5. It is thus imperative to find ways to more accurately assist community colleges and their students in planning the educational pathways, programs, and services that prevent students from stumbling over necessary math requirements and maximize overall success.

[1]University of Wisconsin–Madison, Madison, WI, USA
[2]Milwaukee Area Technical College, Milwaukee, WI, USA
[3]Texas A & M University–Commerce, Commerce, TX, USA

Corresponding Author:
Xueli Wang, University of Wisconsin–Madison, 270-H Education Building, 1000 Bascom Mall, Madison, WI 53706, USA.
Email: xwang273@wisc.edu

Keywords
community college, math requirement, course-taking, curriculum review, transcript analysis

From its inception, the community college core curriculum has consisted of courses in the liberal arts and sciences, including mathematics (Bragg, 2011; Cohen, Brawer, & Kisker, 2014).[1] Furthermore, it is widely acknowledged that competence in math is critical to students' successful educational progress in a community college context (Bragg, 2011); yet, the success rates of completing math courses both at and beyond the developmental level are abysmal (Adelman, 2004; Bailey, Jeong, & Cho, 2010; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Among aspiring community college students who are referred to developmental math, only 31% completed the required sequence (Bailey, 2009). The completion rates are even lower, dropping to 22%, for students who start their developmental math sequence three levels below the college level (Bailey, 2009). While slightly higher, the completion rates for college-level math (45.59%) are equally troublesome (Bahr, 2008). Research has indicated that, as students pass the necessary introductory courses, including those in math, the probability of their credential completion increases considerably (Adelman, 2006; Calcagno, Crosta, Bailey, & Jenkins, 2007). It follows then, if college-level math requirements are fulfilled in a timely fashion, students are on a promising trajectory toward timely completion of their educational programs at 2-year colleges.

Many community college students struggle to complete required math courses, let alone a full set of degree requirements. Research has suggested that a lack of information regarding various institutional and program policies, one being the requirements or sequencing of courses (Jenkins & Cho, 2012; Rosenbaum, Deil-Amen, & Person, 2006), is usually to blame. Although there typically exist recommended sequences for taking program-specific courses during specific academic terms, it is much less clear as to when to take general education courses, including math requirements, within a certain time frame. Students may choose not to enroll in math courses early on because of insufficient advising, conflict with other commitments (Cullinane & Treisman, 2010), or a lack of self-efficacy in learning math (Lent, Lopez, & Bieschke, 1993; Waller, 2006). A large proportion of community college students are not following the appropriate course sequence in math (Cullinane & Treisman, 2010), which may eventually lead to low success rates. As a result, it is critical to look beyond the binary question of whether or not students are completing their required math and examine when exactly students fulfill their math requirements and how this timing relates to their college completion. In this study, we ask the following research question:

> **Research Question:** What is the relationship between the timing of math requirement fulfillment and community college students' college graduation?

When exploring this linkage, we also give a full account of students' educational experiences by combining community college student engagement data with administrative records and transcript data. By focusing on the timing of math requirement fulfillment, we offer new empirical insight into math completion and its connection with student progression and completion at community colleges.

Relevant Literature

Of all course subjects at the college level, math is arguably one of the most critical, given its foundational role in shaping future academic success. As indicated by numerous empirical studies, completion of college-level math is positively related to students' college persistence and completion (Adelman, 2005; Calcagno et al., 2007; Crisp, Nora, & Taggart, 2009; Leinbach & Jenkins, 2008; Roksa & Calcagno, 2010). As such, college-level math classes are often referred to as *gatekeeper courses* (Calcagno et al., 2007; Roksa et al., 2009). As suggested by Leinbach and Jenkins (2008), who studied patterns of community college students' progress and achievement through analyzing *milestones* and *momentum points*, completing a college-level math sequence was substantially related to earning a community college credential or transferring to a baccalaureate institution. Similarly, Adelman's (2005) analysis of data from the National Educational Longitudinal Study of 1988 (NELS:88/2000) revealed that earning college-level math credits increased the probability of degree completion among community college students. These results align with other studies (Calcagno et al., 2007; Roksa & Calcagno, 2010), which collectively establish math requirement fulfillment as a pivotal foundation underlying subsequent progress and success among community college students.

Despite the compelling and consistent evidence highlighting the importance of completing required math courses at community colleges, the picture is less clear with regard to the specific timing of fulfilling math requirements and its relationship to student success. Intuitively, earlier fulfillment of such requirements should be desirable; in reality, many community college students follow *chaotic* course-taking patterns and sequences (Crosta, 2014; Maxwell et al., 2003; Zeidenberg & Scott, 2011). For example, focusing on degree- and transfer-seeking students at five community colleges in a single state, Crosta (2014) identified thousands of distinct enrollment patterns followed by students. Therefore, empirically analyzing when math requirement fulfillment occurs and how the different timing of such fulfillment relates to student outcomes represent a pressing issue of concern for researchers and practitioners.

Although there exist studies that deal with the issue of timing broadly, such research tends to focus on a liberal definition of the time window, such as completing a college-level math course within 2 years of initial enrollment (Leinbach & Jenkins, 2008; Offenstein, Moore, & Shulock, 2010), and subsequent terms are often not accounted for in their analyses (Crisp et al., 2009). Also, research concerning college-level math tends to concentrate solely on fulfilling the first college-level math course, as opposed to including the entire required sequence, and examines by credit accumulation as opposed to timing (Adelman, 2005; Calcagno et al., 2007). Given the transient and less-structured nature of community college attendance as compared with a 4-year college attendance model, these previous studies, despite their great value, do not necessarily offer a nuanced understanding of the specific time points of math requirement fulfillment, such as a term-by-term examination, that could truly inform curricular and program design, policy, and interventions.

Finally, current research using course-taking patterns barely considers other student behaviors, especially how students engage in educationally meaningful activities, that could serve as extraneous factors. The positive role of college engagement in promoting student learning, persistence, and success is widely noted (Pascarella & Terenzini, 2005), particularly at the 4-year college level (Kuh, 2001, 2003; Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008), and recently, in the community college setting (Kuh, 2009; Marti, 2009). In particular, research remains scarce that investigates student engagement as an added contextual layer to better understand the relationship between math course-taking and community college student success. Attending to such understudied nuances as the specific timing of math requirement fulfillment and student engagement behaviors, we explore community college students' term-by-term math requirement fulfillment in conjunction with their college engagement behaviors to understand its influence on students' college success.

Method

Conceptual Grounding

This study is grounded in the concept of *academic momentum*, a term used to capture the choices and behaviors that are positively related to student progression toward degree completion (Adelman, 1999, 2006). First put forward by Adelman (1999) to study 4-year college students' baccalaureate degree completion, the concept of academic momentum has also been adopted to study community college student success (Adelman, 2005; Doyle, 2009, 2010; Leinbach & Jenkins, 2008; Wang, 2015). Completion of college-level math courses is one of the measurable educational achievements (also referred to as *milestones*) that indicates students' momentum toward educational attainment (Adelman, 2005; Calcagno et al., 2007; Crisp et al., 2009; Leinbach & Jenkins, 2008; Roksa & Calcagno, 2010). To obtain more accurate estimates, we also accounted for other individual and institutional factors, such as student background information, college engagement behaviors, and postsecondary contextual factors, as suggested by prior literature (e.g., Adelman, 1999, 2006; Cabrera, Burkum, & La Nasa, 2005; Cabrera, Burkum, La Nasa, & Bibo, 2012; Calcagno et al., 2007; Crisp & Nora, 2010; Crisp et al., 2009; Deil-Amen, 2011; Kuh, 2001, 2003, 2009; Marti, 2009; Pascarella & Terenzini, 2005; Porchea, Allen, Robbins, & Phelps, 2010; Roksa & Calcagno, 2010; Wang, 2015).

Data and Sample

Data from this study come from a comprehensive 2-year college located in an urban area in the Midwest. In spring 2012, students enrolled at the college participated in the

Community College Survey of Student Engagement (CCSSE). Based on the survey administration protocol developed by CCSSE, a random sample of all credit courses was selected, where students received an informed consent sheet and a pencil-and-paper survey questionnaire. Students who chose to participate in the survey completed the paper questionnaires and, if they wished, provided student IDs that could be linked with academic records. At the college, a total of 2,358 students were invited to take the survey and 1,466 participated in the study by returning a completed survey questionnaire, for a response rate of 62.2%. Out of those who completed the survey, 1,041 students (70%) provided a valid student ID. For the purpose of our study, we further retained participants who were new students in an academic program during the school year of 2011-2012 and had math course requirement(s) to graduate from their programs, resulting in an analytical sample of 326 students. Because of other statistical considerations, the final analytical sample size was 320. For the current study, we followed these students' enrollment records upto spring 2014.

Given the sample restrictions and that the data were collected from a single institution, the study sample is not necessarily representative of community college students' characteristics nationally. For example, 68.7% of the participants in our study were full-time students, whereas, nationally, less than 40% of community college students in fall 2013 were enrolled full-time (American Association of Community Colleges [AACC], 2015a). However, our sample does reflect the racial composition among community college students nationally (AACC, 2015b); in fall 2013, 50% of community college students nationally were White, 21% were Hispanic, and 14% were Black. Whereas our sample included a higher proportion of Black students (21.3%) and a lower portion of Hispanic students (12.3%), compared with the national averages, the percentage of White (51.5%) students is nearly identical to the national statistic.

Measures and Data Analysis

To answer our research question, we proceeded with data preparation and analysis in the following steps. First, we performed a careful examination of students' college-level math requirements in alignment with the programs and tracks in which they first enrolled. This process involved a labor-intensive, detailed review of published math requirements across all programs and tracks at the college. Following this step, we coded students' fulfillment of all their math requirements based on the transcript data and operationalized this definition term by term. Note that the effect of math fulfillment within each of these specific terms was compared against the scenario in which a student did not fulfill all required math during the specific term (i.e., the reference group of math fulfillment status of each term). In the survival analysis, our main analytical approach described below, this math completion variable was entered as a set of dummy variables.

For our dependent variable, we measured college success as whether students completed a community college credential as of spring 2014. We further controlled for a number of important covariates that may be relevant to college success. In particular, we accounted for students' college engagement behaviors using the five benchmark scores collected by the CCSSE survey: active and collaborative learning, student effort, academic challenge, student–faculty interaction, and college support for learners. According to CCSSE's *Student Engagement and Student Outcomes: Key Findings From CCSSE Validation Research* report (McClenney, Marti, & Adkins, 2006), active and collaborative learning measures the extent to which students participate in class, interact with peers, and learn outside of the classroom. Student effort measures time on task, preparation, and use of campus services. Academic challenge reflects the extent to which students engage in challenging mental activities (e.g., evaluation and synthesis), and quantity and rigor of academic work. Student–faculty interaction items are used to measure the extent to which students and faculty communicate about academic performance, career plans, and course content and assignments. With regard to support for learners, the items measure students' perceptions of their college and evaluate their use of advising and counseling services. We also controlled for students' prior math preparedness, their program of study, their full-time enrollment status, as well as demographic background. Table 1 offers a detailed description of these variables. Approximately, 1.8% of the cases in our study had missing values, or 0.09% of the data points were missing, which were primarily found in the CCSSE benchmark variables. Given the small portion of the missing data points, listwise deletion was applied as it would have a limited impact on the analyses (Graham, 2009).

We estimated a Cox regression model, a type of survival analysis, to answer the research question. Survival analysis has been noted as an appropriate technique to address time-sensitive student behaviors and outcomes, such as enrollment patterns over time and graduation (Bahr, 2009), and has gained traction in recent research (Calcagno et al., 2007). Survival analysis models whether and when an event occurs (Singer & Willett, 2003). In the context of our study, a Cox regression model describes a log transformation of the hazard ratio (i.e., the *risk* of graduation in a specific term relative to the first term) as a linear function of predictors. Specifically, the metric of the hazard function of our model is estimated as follows, with β denoting the coefficient, X the completion of students' math requirements in a specific term, and C the covariates: $\log(h(t_{ij}) / h_0(t_j)) = \beta_1 X_{1ij} + \beta_2 X_{2ij} + \ldots + \beta_6 X_{6ij} + \beta_7 C_{1i} \ldots + \beta_p C_{(p-6)i}$, where hazard, conventionally denoted as $h(t_{ij})$, is expressed as the risk that individual i will complete a credential in Term j, given that he or she did not graduate in any of the proceeding terms. X_{kij} identifies the completion of math requirements in the kth term, which is a time-varying variable, being 0 when $j < k$ and 1 when $j \geq k$. As for the results, the parameters are interpreted in terms of a covariate's effect on the hazard ratio, and the effects are assumed to be constant over time. Moreover, for ease of interpretation, the antilog of each coefficient, $e^{(\text{coefficient})}$, is used to describe the effect of a 1-unit change in the particular covariate on the hazard ratio. Finally, based on the estimated Cox regression model, we calculated the predicted survival rate (i.e., nongraduation rate) and performed a nonparametric bootstrapping with 1,000 iterations to compare the predicted graduation probability by spring 2014 (i.e., the final term in our analysis) of students who completed their math requirements in different terms.

Table 1. Variables in the Study and Descriptive Statistics.

Variable name	%	*M*	*SD*	Definition
Dependent variable				
Credential completion	31.6			Whether students completed a community college credential starting in summer 2011 by spring 2014
Independent variable				
Timing of math requirement fulfillment				
No completion	54.6			The term when students fulfilled 100% of their college-level math requirements, with no 100% completion of any required math as the reference category
Summer/fall 2011	6.1			
Spring 2012	12.9			
Summer/fall 2012	9.5			
Spring 2013	6.1			
Summer/fall 2013	3.1			
Spring 2014	4.6			
Postsecondary experience				
Program of study	23.0			Whether students are enrolled in manufacturing and engineering programs as compared with other programs
Full-time enrollment status	68.7			Whether students were enrolled full-time (coded 1) or part-time (coded 0)
Program type: less-than-1-year technical diploma program	5.5			Whether students are enrolled in a less-than-1-year technical diploma program in AY12
Program type: 1-year technical diploma program	13.5			Whether students are enrolled in a 1-year technical diploma program in AY12
Program type: 2-year technical diploma program	0.9			Whether students are enrolled in a 2-year technical diploma program in AY12
Program type: associate degree program	80.1			Whether students are enrolled in an associate degree program in AY12 (was the omitted reference category in the survival analysis)
Student college engagement behavior				CCSSE's five engagement benchmark scores
Active and collaborative learning		0.40	0.17	
Student effort		0.47	0.16	
Academic challenge		0.60	0.17	

(continued)

Table 1. (continued)

Variable name	%	*M*	*SD*	Definition
Student-faculty interaction		0.41	0.18	
Support for learners		0.47	0.22	
Demographic background controls				
Female	31.0			Respondent's gender; dummy variable (coded 1 for females and 0 for males)
Age		27.52	10.54	Respondent's age
Black	27.3			Dummy variable (coded 1 for African Americans)
Hispanic	12.3			Dummy variable (coded 1 for Hispanics)
Other race/ethnicity	8.9			Dummy variable (coded 1 for Asians, Indian Americans, and Unknowns combined)
White	51.5			Dummy variable (coded 1 for White and was the omitted reference category in the survival analysis)
Math ready	34.4			Whether students passed the arithmetic placement test upon enrolling in college

Note. For CCSSE items and details of student engagement benchmarks, please refer to http://www.ccsse.org. AY = academic year; CCSSE = Community College Survey of Student Engagement.

Discussion of Results

The Cox regression analysis revealed that, across all academic terms, there was a significant and positive relationship between completion of math requirements and graduation by spring 2014 (see Table 2). Among specific milestones, students had a relatively higher chance to graduate by spring 2014 if they completed all their required math courses during the first, fourth, or fifth terms (see Table 3). In essence, the students who fulfilled all required math by the first, fourth, or fifth semesters tended to be 4, 6, and 9 times more likely to graduate than those who did not achieve such milestones. The predicted survival probability further revealed that the nongraduation probability as of the sixth term for the students who completed all required math courses in the first (31.2%), fourth (27.9%), and fifth terms (27.7%) is somewhat smaller than those who completed their math courses in any of the other terms (see Table 3). In particular, the students who completed all required math courses in summer/fall 2011 (i.e., the first term) were estimated to have a better graduation rate by spring 2014 than those who did so in summer/fall 2012 (i.e., the third term; one-tail bootstrapped $p = .08$).

Among the CCSSE indicators, student engagement in active and collaborative learning was positively related to credential completion, whereas engaging in student-faculty interaction was negatively related to credential completion. Furthermore, the students

Table 2. Summary of Survival Analysis.

Independent variable	*B*	*SE*	Hazard ratio
Timing of math requirement fulfillment			
Summer/fall 2011	1.40***	0.17	4.06
Spring 2012	1.17***	0.16	3.21
Summer/fall 2012	0.94***	0.20	2.56
Spring 2013	1.85***	0.22	6.38
Summer/fall 2013	2.18***	0.34	8.89
Spring 2014	2.42***	0.37	11.26
Postsecondary experience			
Program of study	0.52***	0.14	1.69
Full-time enrollment status	0.54***	0.13	1.72
Program: shorter than 1-year TD	0.67**	0.21	1.95
Program: 1-year TD	0.15	0.16	
Program: 2-year TD	0.74*	0.37	2.10
Student college engagement behavior			
Active and collaborative learning	1.73***	0.39	5.66
Student effort	0.26	0.39	
Academic challenge	0.71†	0.42	2.04
Student-faculty interaction	−1.49***	0.37	0.23
Support for learners	0.54†	0.30	1.72
Demographic background controls			
Female	0.50***	0.11	1.64
Age	0.02***	0.00	1.02
Black	−0.39**	0.13	0.68
Hispanic	−0.17	0.16	
Other race/ethnicity	−0.48*	0.21	0.62
Math ready	−0.01	0.11	

Note. Only statistically significant predictors' hazard ratios are reported. Also note that coefficients of Cox regression represent the change in the expected log of the hazard ratio relative to a one unit change in a given independent variable holding all other predictors constant, and is not to be confused with log odds as in logistic regression.
TD = technical diploma.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

who found the academics challenging and those who felt academically supported tended to have a higher graduation rate. The students in the shorter term and 2-year technical diploma programs had a higher rate of graduation than the students in the associate degree programs. Finally, female, older, and White students (as compared with Black and other race/ethnicity) tended to have a higher probability of degree completion.

Our findings demonstrate a general positive link between math completion and credential completion. This empirical finding is well substantiated by the rich existing literature documenting math's strong predictive power for later achievement (Adelman, 1999, 2005, 2006; Cabrera et al., 2005; Cabrera et al., 2012; Calcagno et al., 2007;

Table 3. Predicted Survival Probability.

	Graduation term					
Math completion term	Summer/fall 2011 (%)	Spring 2012 (%)	Summer/fall 2012 (%)	Spring 2013 (%)	Summer/fall 2013 (%)	Spring 2014 (%)
Summer/fall 2011	72.5	55.7	44.4	37.9	33.7	31.2
Spring 2012	NA	77.5	62.9	52.6	46.4	42.3
Summer/fall 2012	NA	NA	81.6	69.1	59.9	54.2
Spring 2013	NA	NA	NA	60.3	39.8	27.9
Summer/fall 2013	NA	NA	NA	NA	49.4	27.7
Spring 2014	NA	NA	NA	NA	NA	41.0

Note. Cell entries are estimated survival probability (i.e., probability of nongraduation). NA indicates that students are not eligible to graduate, in that they have to complete all the required math courses.

Roksa & Calcagno, 2008). In addition to this expected general finding, more intriguing and detailed findings surface from our analysis that tell a more nuanced picture of when the optimal timing is to complete required math. Although aligning with conventional wisdom suggesting that the earlier students fulfill their math requirements the better (Leinbach & Jenkins, 2008; Offenstein et al., 2010), the Cox regression model and bootstrapped survival probability revealed that not only the first but also the fourth and fifth terms represent optimal timings for completing required math.

The fourth or fifth terms being optimal timing to fulfill math represents a divergent but beneficial pathway toward building momentum. Students can still develop appropriate momentum for subsequent success without feeling rushed, especially for those uncertain of an academic major upon initial enrollment in college. Students have the opportunity to explore various subjects before committing to a particular field of study. In other words, to stay in college and persist to completion, students do not have to complete math requirements as early as the very first semester of enrollment. Students may explore and get to know a disciplinary context before taking relevant required math courses. By doing so, they may contextualize their math learning in their field of interest.

In the community college context, some students making the transition to college may not be immediately ready to take on a college-level math course (Cohen et al., 2014), regardless of whether or not they enroll in college directly after high school. For these students, taking other courses first, especially field-specific introductory courses, to have a sense of the expectations and requirements can be a practical and viable approach. These insights gained through taking introductory courses can be used as a foundation for self-evaluation and consequently provide a better understanding of how to prepare for their field of interest. Students may then become more intentional in planning their educational trajectory, see the applicability of coursework to their future career, and ultimately be more motivated and determined to learn.

Apart from exploring fields of study and cultivating academic readiness, other students may have more pressing program requirements that take priority over math. Most important, given the abstract nature of math (i.e., lacking concrete or real-world application) and students' underpreparedness in math (Grubb, 2010; Grubb et al., 1999), fulfilling necessary math courses may require a substantial amount of time and effort, particularly if there are other course components involved (e.g., lab). Many community college students may not have adequate time and effort to devote to math, especially if they have outside responsibilities such as work and family (Bryant, 2001; Cohen et al., 2014; Deil-Amen, 2011). To persist toward credential completion, students must complete college math requirements in a timely way. However, we argue that the definition of *timely*, in light of earning a credential as an outcome, should be more liberal than what policymakers and administrators may currently have in mind (e.g., the very first term), given our finding illuminating that the later terms also represent beneficial timing.

To some extent, these findings resonate with previous studies that contend the positive impact of milestone attainment, such as passing college-level *gatekeeper* courses, on degree completion (Adelman, 2006; Calcagno et al., 2007; Leinbach & Jenkins, 2008). Similarly, recent initiatives aiming to accelerate community college students' progress through developmental math, such as Statway®, also show the promise of early completion of developmental math in positively influencing the accumulation of college-level credits (Yamada & Bryk, 2016). Diverging from previous studies (Leinbach & Jenkins, 2008; Offenstein et al., 2010), our findings suggest that students can enjoy a similar probability of graduation by completing their math requirements later, in Terms 4 or 5, as those who completed their required math courses in the first semester after enrollment. In a sense, students who are not able to complete their math requirements early on in their academic career should not be discouraged as long as they fulfill those requirements by Terms 4 or 5. Moreover, our results unveil some of the nuances underneath the muddy realities of math course-taking at community colleges (Hagedorn, Maxwell, Cypers, Moon, & Lester, 2007) and suggest that these institutions should utilize the first three academic terms as a viable window for instruction, advising, and other educational practices aimed at helping students move forward and complete math requirements by the fourth or fifth terms to improve credential completion at community colleges.

Several other findings are also worth discussing. Students' active and collaborative learning was positively related to degree completion. This is a reasonable finding, especially when considering that, as a student becomes more engaged individually and with others in learning, they should reap larger benefits in areas such as academic success and completion. What does this look like in the community college setting? At these institutions, the majority of engagement or any other integrative or involvement practices happen in the classroom (Deil-Amen, 2011). Classrooms may serve as small learning communities that prompt students to become involved and engaged (Tinto, 1997), which can subsequently foster positive academic performance and lead to a higher likelihood of completion.

Academic challenge and support for learners are the other two student college engagement behavior measures that appeared to have a significantly positive relationship with credential completion. Indicators of academic challenge, such as higher order thinking and rigor of academic work, have been shown to be related to academic outcomes

(McClenney et al., 2006). Students who reported a higher score on academic challenge items were more likely to graduate. In terms of support for learners, it is possible that students benefited from advising and counseling services, which in turn increased their likelihood of graduation. Advising and counseling services help students map out their program trajectory or progress and point them in the direction of additional supports if needed. This would apply to many individuals who seek assistance with fulfilling their program requirements, including math, and successfully completing a credential.

Another intriguing finding is that interaction with faculty was negatively related to credential completion. It could be possible that students reporting higher scores on the student–faculty interaction scale happened to be those who were more academically disadvantaged. Thus, they may interact with instructors more frequently because they have particular learning or support needs or poor academic performance (Marti, 2009). Another perspective that warrants consideration is the value of interaction with faculty in and of itself. There is emerging empirical evidence indicating that, if faculty's approaches to teaching inadvertently result in an invalidating environment, students may experience stereotype threat, tempered aspirations, and lowered academic self-confidence and self-efficacy, which then translate into negative academic outcomes (Acevedo-Gil, Santos, Alonso, & Solorzano, 2015). Nonetheless, these results warrant further exploration in future inquiry.

In addition, aligning with previous research (e.g., Adelman, 1999; Calcagno et al., 2007), full-time enrollment was found to have a significant, positive relationship with credential completion. In terms of enrollment in manufacturing and engineering programs, there was a positive correlation with credential completion. Although some of these programs require algebra-level math, many do not have any formal math skill requirements to gain admission. Students may have greater access to these programs. At the same time, it is possible that these programs, regardless of their basic or no math requirements for entry, contain students who have a predisposition to having a higher level of academic performance and more advanced math course training coming into college (Chen & Weko, 2009), which would carry into positive college performance and completion. One other possible explanation is that manufacturing and engineering programs—with their strong technical and vocational components—present more frequent venues for a more contextualized application of math concepts, which is positively linked to students' understanding of math, academic performance, and completion of a credential (Jenkins, Zeidenberg, & Kienzl, 2009). Another finding to note, students enrolled in 2-year and less-than-1-year terminal degree programs were more likely to obtain a credential compared with students in associate degree program. It is likely that students enroll in these programs for the purpose of gaining certain skills for job advancement with clear vocational goals and are more likely to progress and graduate. This finding also aligns with prior research suggesting that more degrees are awarded annually in vocational fields than in liberal arts (e.g., Townsend, 2001).

Last, students who were female, older, or White (as compared with Black and other race/ethnicity) were more likely to complete a credential compared with their counterparts. These findings are consistent with prior research (Bailey, Jenkins, & Leinbach, 2005; Calcagno et al., 2007). Older students, including the many females concentrated at community colleges, have external responsibilities, such as work or family (Bryant, 2001; Cohen et al., 2014; Deil-Amen, 2011; St. Rose & Hill, 2013). These obligations may put pressure on them to persist and graduate for the purpose of job advancement or bringing home higher earnings. As for the differences in the likelihood of completion across race/ethnicity, this finding illuminates a persistent gap in community college student outcomes as evidenced in previous scholarly work (Bailey et al., 2005; Greene, Marti, & McClenney, 2008), warranting further empirical attention.

Limitations

There are a few limitations that should be carefully considered when interpreting the results of this study. First, there is the inherent issue of self-selection in relation to students who participated in the survey and further provided consent allowing us to track their student records. Second, this study does not cover more intermediate milestones, such as term-by-term course completion, which may help more accurately track students' progress and understand how different intermediary points may be related to academic performance and completion. Third, although the findings show which terms were associated with a higher probability of credential completion, there is no definitive answer as to why certain terms resulted in more or less beneficial outcomes, given the correlational nature of our analyses.

Finally, our study constrained the timing of completion within 3 years from the start of students' program of study. We operationalized this outcome measure within the confines of the study's scope and available data. Still, we acknowledge that 3 years may not represent a sufficient and appropriate time frame to measure the educational success of all sampled students. Community colleges serve a large share of students of color and low-income students, who tend to take a longer time to complete their credential (Ma & Baum, 2016). In addition, many community college students enroll part-time (Cohen et al., 2014) or switch their enrollment often (Crosta, 2014). The time and other constraints often facing these students make the measurement of their success a much more complex matter. With these limitations in mind, our research sets a foundation that would be complemented by qualitative research to extend these results and provide additional context and understanding that could not be provided in our study.

Implications for Policy, Practice, and Research

This study has several implications for policy, practice, and research. First, by focusing on specific points at which community college students fulfill math requirements and their relationships with long-term college success, this research provides empirical evidence that informs course and program sequences and academic advising at both the research site and other similar community colleges. As our findings indicate, completing college-level math early on, especially in the first term, or later, in the fourth or fifth terms of enrollment, greatly contributed to students' credential completion. Nevertheless, realizing the chaotic and varied enrollment patterns and educational pathways students choose during their academic career (Crosta, 2014), community colleges should purposefully design course sequences along with advising services that communicate clearly articulated course pathways and guide students toward a more efficient path to earning a credential. This is by no means advisors' responsibility only. As faculty also interact with students frequently and closely, they can also serve as valuable institutional agents who advocate for and support early or later college-level math course-taking behavior. Acknowledging the role of college-level math, instructors, especially those who teach introductory college-level math courses, should consider adopting high-impact practices, such as contextualization (Perin, 2011; Wang, Sun, & Wickersham, forthcoming), active learning (Michael & Modell, 2003; Prince, 2004; Wang, Sun, Lee, & Wagner, 2015), and cooperative learning (Nasr, Pennington, & Andres, 2004) that could help students successfully complete these courses. As an incentive for community colleges to reinforce practices that encourage early college-level math course-taking behavior, policymakers could also consider including such criteria when designing metrics for evaluating college performance.

Second, findings from this study illuminate active and collaborative learning as a promising approach that could contribute to credential completion for community college students. A rich body of research has linked active learning to numerous desired academic outcomes, such as critical thinking and problem-solving skills, transfer intent, grade point average (GPA), persistence, and degree completion (Braxton, Milem, & Sullivan, 2000; Freeman et al., 2014; Hake, 1998; Kim, Sharma, Land, & Furlong, 2013; Wang et al., 2015). In light of this empirical evidence, community colleges should consider implementing pedagogies that actively engage students in the learning process. To invite and support faculty members in adopting innovative teaching approaches, professional development of community college instructors represents a particularly viable and essential approach.

Third, this study invites researchers and community college practitioners to consider the use of curriculum review and transcript analysis to better understand student academic behaviors and pathways. As sources of data that already exist, program curricula and students' transcripts do not require new resources for data collection, thus offering robust, cost-efficient extant sources of information. Unlike other studies focusing on student enrollment behavior that solely rely on transcript data, this study also integrates curricular and transcript records with survey data that account for students' college engagement. This approach helps create a more nuanced and contextualized understanding of the topic under study by considering a more holistic set of student behaviors. Colleges interested in seeking reasons behind student choices could also supplement curriculum review and transcript analysis with individual or focus group interviews with students to explain the observed behaviors. Community colleges should carefully consider these behaviors so that they may design policies, interventions, and services that best serve their students and facilitate math requirement fulfillment and future academic success.

Conclusion

Going beyond whether community college students complete math requirements, this study examined the timing of students' math course completion and the relationship to their credential completion. In doing so, we present a more contextual and nuanced understanding of community college math offerings and related student behaviors in connection with student progression and completion. Our findings reveal that fulfilling college-level math requirements early on promises higher odds of credential completion. However, this momentum can be achieved by completing math requirements in Term 1, or it can also be delayed until Terms 4 or 5. Nevertheless, our findings reinforce the critical nature of math in general in setting students on a successful educational trajectory. Adding the component of student background and engagement behavior, we are able to lend more complex insight into math requirement fulfillment at the student level within the community college context. As a result, we can begin to find ways to more accurately assist community colleges and their students in planning the educational pathways, programs, and services that prevent students from stumbling over necessary math requirements, move beyond them, and maximize overall success.

Acknowledgments

The authors thank Yen Lee for research assistance, as well as Jaime Lester and anonymous reviewers for valuable feedback on earlier versions of this study.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The National Science Foundation (Award No. 110426) provided funding for this study. Any opinions, findings, and conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Note

1. Mathematics is hereafter referred to as math.

References

Acevedo-Gil, N., Santos, R. E., Alonso, L., & Solorzano, D. G. (2015). Latinas/os in community college developmental education: Increasing moments of academic and interpersonal validation. *Journal of Hispanic Higher Education*, *14*, 101-127. doi:10.1177/1538192715572893

Adelman, C. (1999). *Answers in the toolbox: Academic intensity, attendance patterns, and bachelor's degree attainment*. Washington, DC: U.S. Department of Education. Retrieved from http://www2.ed.gov/pubs/Toolbox/toolbox.html

Adelman, C. (2004). *Principal indicators of student academic histories in postsecondary education, 1972-2000*. Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/rschstat/research/pubs/prinindicat/prinindicat.pdf

Adelman, C. (2005). *Moving into town—and moving on: The community college in the lives of traditional-age students*. Washington, DC: U.S. Department of Education. Retrieved from http://www2.ed.gov/rschstat/research/pubs/comcollege/movingintotown.pdf

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. Washington, DC: U.S. Department of Education. Retrieved from https://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

American Association of Community Colleges. (2015a). *Data point: Attendance trends*. Retrieved from http://www.aacc.nche.edu/Publications/datapoints/Documents/Attendance_final.pdf

American Association of Community Colleges. (2015b). *Data point: Enrollment at community colleges*. Retrieved from http://www.aacc.nche.edu/Publications/datapoints/Documents/EnrollmentCC_4.pdf

Bahr, P. R. (2008). Does mathematics remediation work? A comparative analysis of academic attainment among community college students. *Research in Higher Education*, *49*, 420-450. doi:10.1007/s11162-008-9089-4

Bahr, P. R. (2009). Educational attainment as process: Using hierarchical discrete-time event history analysis to model rate of progress. *Research in Higher Education*, *50*, 691-714. doi:10.1007/s11162-009-9135-x

Bailey, T. R. (2009). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New Directions for Community Colleges*, *2009*(145), 11-30. doi:10.1002/cc.352

Bailey, T. R., Jenkins, D., & Leinbach, D. T. (2005). *What we know about community college low-income and minority student outcomes: Descriptive statistics from national surveys*. New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/low-income-minority-completion.pdf

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

Bragg, D. D. (2011). Two-year college mathematics and student progression in STEM programs of study. In S. Olson & J. B. Labov (Eds.), *Community colleges in the evolving STEM education landscape: A summit* (pp. 81-106). Washington, DC: National Academies Press. doi:10.17226/13399

Braxton, J. M., Milem, J. F., & Sullivan, A. S. (2000). The influence of active learning on the college student departure process: Toward a revision of Tinto's theory. *The Journal of Higher Education*, *71*, 569-590. doi:10.2307/2649260

Bryant, A. N. (2001). ERIC review: Community college students recent findings and trends. *Community College Review*, *29*(3), 77-93. doi:10.1177/009155210102900305

Cabrera, A. F., Burkum, K. R., & La Nasa, S. M. (2005). Pathways to a four-year degree: Determinants of transfer and degree completion. In A. Seidman (Ed.), *College student retention: Formula for student success* (pp. 155-209). Westport, CT: Praeger.

Cabrera, A. F., Burkum, K. R., La Nasa, S. M., & Bibo, E. W. (2012). Pathways to a four-year degree: Determinants of degree completion among socioeconomically disadvantaged students. In A. Seidman (Ed.), *College student retention: Formula for student success* (2nd ed., pp. 167-210). Lanham, MD: Rowman & Littlefield.

Calcagno, J. C., Crosta, P. M., Bailey, T., & Jenkins, D. (2007). Stepping stones to a degree: The impact of enrollment pathways and milestones on community college student outcomes. *Research in Higher Education*, *48*, 775-801. doi:10.1007/s11162-007-9053-8

Chen, X., & Weko, T. (2009). *Stats in brief: Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education*. Washington, DC: National Center of Education Statistics. Retrieved from http://nces.ed.gov/pubs2009/2009161.pdf

Cohen, A. M., Brawer, F. B., & Kisker, C. B. (2014). *The American community college* (6th ed.). San Francisco, CA: Jossey-Bass.

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., & 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*, 924-942. doi:10.3102/0002831209349460

Crosta, P. M. (2014). Intensity and attachment: How the chaotic enrollment patterns of community college students relate to educational outcomes. *Community College Review*, *42*, 118-142. doi:10.1177/0091552113518233

Cullinane, J., & Treisman, P. U. (2010, September). *Improving developmental mathematics education in community colleges: A prospectus and early progress report on the Statway initiative*. Paper presented at the NCPR Developmental Education Conference, New York, NY.

Deil-Amen, R. (2011). Socio-academic integrative moments: Rethinking academic and social integration among two-year college students in career-related programs. *The Journal of Higher Education*, *82*, 54-91. doi:10.1353/jhe.2011.0006

Doyle, W. R. (2009). Impact of increased academic intensity on transfer rates: An application of matching estimators to student-unit record data. *Research in Higher Education*, *50*, 52-72. doi:10.1007/s11162-008-9107-6

Doyle, W. R. (2010). Effect of increased academic momentum on transfer rates: An application of the generalized propensity score. *Economics of Education Review*, *30*, 191-200. doi:10.1016/j.econedurev.2010.08.004

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*, 8410-8415. doi:10.1073/pnas.1319030111

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology*, *60*, 549-576. doi:10.1146/annurev.psych.58.110405.085530

Greene, T. G., Marti, C. M., & McClenney, K. (2008). The effort-outcome gap: Differences for African American and Hispanic community college students in students engagement and academic achievement. *The Journal of Higher Education*, *79*, 513-539. doi:10.1353/jhe.0.0018

Grubb, W. N. (2010, September). *The quandaries of basic skills in community colleges: Views from the classroom*. Paper presented at the NCPR Developmental Education Conference, New York, NY.

Grubb, W. N., Worthen, H., Byrd, B., Webb, E., Badway, N., Case, C., . . . Villeneuve, J. C. (1999). *Honored but invisible: An inside look at teaching in community colleges*. New York, NY: Routledge.

Hagedorn, L. S., Maxwell, W. E., Cypers, S., Moon, H. S., & Lester, J. (2007). Course shopping in urban community colleges: An analysis of student drop and add activities. *The Journal of Higher Education*, *78*, 464-485. doi:10.1353/jhe.2007.0023

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*, 64-74. doi:10.1119/1.18809

Jenkins, D., & Cho, S.-W. (2012, January). *Get with the program: Accelerating community college students' entry into and completion of programs of study* (CCRC Working Paper No.

32). New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/accelerating-student-entry-completion.pdf

Jenkins, D., Zeidenberg, M., & Kienzl, G. S. (2009, May). *Educational outcomes of I-BEST, Washington State Community and Technical College System's Integrated Basic Education and Skills Training Program: Findings from a multivariate analysis* (CCRC Working Paper No. 16). New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/educational-outcomes-of-i-best.pdf

Kim, K., Sharma, P., Land, S. M., & Furlong, K. P. (2013). Effects of active learning on enhancing student critical thinking in an undergraduate general science course. *Innovative Higher Education*, *38*, 223-235. doi:10.1007/s10755-012-9236-x

Kuh, G. D. (2001). Assessing what really matters to student learning inside the National Survey of Student Engagement. *Change: The Magazine of Higher Learning*, *33*(3), 10-17. doi:10.1080/00091380109601795

Kuh, G. D. (2003). What we're learning about student engagement from NSSE: Benchmarks for effective educational practices. *Change: The Magazine of Higher Learning*, *35*(2), 24-32. doi:10.1080/00091380309604090

Kuh, G. D. (2009). The national survey of student engagement: Conceptual and empirical foundations. *New Directions for Institutional Research*, *2009*(141), 5-20. doi:10.1002/ir.283

Kuh, G. D., Cruce, T. M., Shoup, R., Kinzie, J., & Gonyea, R. M. (2008). Unmasking the effects of student engagement on first-year college grades and persistence. *The Journal of Higher Education*, *79*, 540-563. doi:10.1353/jhe.0.0019

Leinbach, D. T., & Jenkins, D. (2008). *Using longitudinal data to increase community college student success: A guide to measuring milestone and momentum point attainment* (CCRC Research Tools No. 2). New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/longitudinal-data-momentum-point-research-tool.pdf

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1993). Predicting mathematics-related choice and success behaviors: Test of an expanded social cognitive mode. *Journal of Vocational Behavior*, *42*, 223-236. doi:10.1006/jvbe.1993.1016

Ma, J., & Baum, S. (2016, April). *Trends in community colleges: Enrollment, prices, student debt, and completion* (College Board Research Brief). Retrieved from http://trends.collegeboard.org/sites/default/files/trends-in-community-colleges-research-brief.pdf

Marti, C. N. (2009). Dimensions of student engagement in American community colleges: Using the community college student report in research and practice. *Community College Journal of Research and Practice*, *33*, 1-24. doi:10.1080/10668920701366867

Maxwell, W., Hagedorn, L. S., Cypers, S., Moon, H. S., Brocato, P., Wahl, K., & Prather, G. (2003). Community and diversity in urban community colleges: Course taking among entering students. *Community College Review*, *30*(4), 21-46. doi:10.1177/009155210303000402

McClenney, K., Marti, C. N., & Adkins, C. (2006). *Student engagement and student outcomes: Key findings from CCSSE validation research*. Austin: Community College Survey of Student Engagement, University of Texas at Austin. Retrieved from https://www.ccsse.org/aboutsurvey/docs/CCSSE%20Validation%20Summary.pdf

Michael, J. A., & Modell, H. I. (2003). *Active learning in secondary and college science classrooms: A working model for helping the learner to learn*. Mahwah, NJ: Lawrence Erlbaum.

Nasr, K., Pennington, J., & Andres, C. (2004). A study of students' assessments of cooperative education outcomes. *Journal of Cooperative Education*, *38*(1), 13-21.

Offenstein, J., Moore, C., & Shulock, N. (2010). *Advancing by degrees: A framework for increasing college completion*. Retrieved from http://edtrust.org/wp-content/uploads/2013/10/AdvbyDegrees_0.pdf

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research*. San Francisco, CA: Jossey-Bass.

Perin, D. (2011). Facilitating student learning through contextualization: A review of evidence. *Community College Review*, *39*, 268-295. doi:10.1177/0091552111416227

Porchea, S. F., Allen, J., Robbins, S., & Phelps, R. P. (2010). Predictors of long-term enrollment and degree outcomes for community college students: Integrating academic, psychosocial, socio-demographic and situational factors. *The Journal of Higher Education*, *81*, 680-708. doi:10.1353/jhe.2010.0014

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*, 223-231. doi:10.1002/j.2168-9830.2004.tb00809.x

Roksa, J., & Calcagno, J. C. (2008, June). *Making the transition to four-year institutions: Academic preparation and transfer* (CCRC Working Paper No. 13). New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/making-transition-four-year-institutions.pdf

Roksa, J., & Calcagno, J. C. (2010). Catching up in community colleges: Academic preparation and transfer to four-year institutions. *Teachers College Record*, *112*, 260-288.

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*. New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/strategies-promoting-gatekeeper-course.pdf

Rosenbaum, J. E., Deil-Amen, R., & Person, A. E. (2006). *After admission: From college access to college success*. New York, NY: Russell Sage.

St. Rose, A., & Hill, C. (2013). *Women in community colleges: Access to success*. Washington, DC: The American Association of University Women.

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press.

Tinto, V. (1997). Classrooms as communities: Exploring the educational character of student persistence. *The Journal of Higher Education*, *68*, 599-623. doi:10.2307/2959965

Townsend, B. K. (2001). Blurring the lines: Transforming terminal education to transfer education. *New Directions for Community College*, *2001*(115), 63-71. doi:10.1002/cc.31

Waller, B. (2006). Math interest and choice intentions of non-traditional African American college students. *Journal of Vocational Behavior*, *68*, 538-547. doi:10.1016/j.jvb.2005.12.002

Wang, X. (2015). Pathway to a baccalaureate in STEM fields: Are community colleges a viable route and does early STEM momentum matter? *Educational Evaluation and Policy Analysis*, *37*, 376-393. doi:10.3102/0162373714552561

Wang, X., Sun, N., Lee, S. Y., & Wagner, B. (2015, November). *Does active learning contribute to transfer intent among community college students beginning in STEM?* Paper presented at the 40th Annual Conference of the Association for the Study of Higher Education, Denver, CO.

Wang, X., Sun, N., & Wickersham, K. (Forthcoming, Spring 2017). Turning math remediation into "homeroom": Contextualization as a motivational environment for remedial math students at community colleges. *The Review of Higher Education*.

Yamada, H., & Bryk, A. S. (2016). Assessing the first two years' effectiveness of Statway®: A multilevel model with propensity score matching. *Community College Review*, *44*, 179-204. doi:10.1177/0091552116643162

Zeidenberg, M., & Scott, M. (2011, October). *The content of their coursework: Understanding course-taking patterns at community colleges by clustering student transcripts* (CCRC Working Paper No. 35). New York, NY: Teachers College, Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/coursework-patterns-clustering-transcript.pdf

Author Biographies

Xueli Wang is an associate professor of higher education in the Department of Educational Leadership and Policy Analysis at the University of Wisconsin-Madison. Her research centers on postsecondary pathways and success of students beginning at community colleges, as well as undergraduate STEM education.

Yan Wang is the Director of Institutional Research at Milwaukee Area Technical College. Her research focuses on program evaluation, student success, and enrollment management in community colleges.

Kelly Wickersham is a doctoral student in the department of Educational Leadership and Policy analysis at the University of Wisconsin-Madison. Her research addresses community college student pathways through higher education and subsequent persistence and success.

Ning Sun is a doctoral student in the department of Educational Leadership and Policy analysis at the University of Wisconsin-Madison. Her research centers around teaching and learning in relation to students' participation and success in STEM fields at the two-year college level.

Hsun-yu Chan is an assistant professor of educational psychology in the Department of Psychology, Counseling, and Special Education, Texas A&M University-Commerce. His research focuses on the how psychosocial factors facilitate learning and academic success for two-year college students in STEM fields.