

Co-Requisite Mathematics Models and Gateway Completion

A Systematic Approach to Leading Change at Scale



Abderrazak Belkharraz Idrissi, Milena Cuellar, and Jeanne Funk
LaGuardia Community College,
City University of New York

About the Author

Abderrazak Belkharraz Idrissi serves as the chairperson of mathematics, engineering and computer science at LaGuardia Community College

Milena Cuellar serves as a professor of mathematics at LaGuardia Community College.

Jeanne Funk serves as a professor of mathematics at LaGuardia Community College.

Idrissi, A., Cuellar, M., & Funk, J. (2018). *Co-requisite mathematics models and gateway completion: A systematic approach to leading change at scale* (Steps to Success series). Denver, CO: Strong Start to Finish, Education Commission of the States.

Acknowledgements

The authors would like to thank the Mathematics, Engineering, and Computer Science faculty who designed, implemented, and revised LaGuardia's co-requisite mathematics courses. This project would not have been possible without the leadership and expertise of faculty. We would also like to thank LaGuardia's Administrative leaders for providing unflagging support throughout; LaGuardia's Center for Teaching and Learning for helping us provide high quality professional development; the Carnegie Math Pathways network for pedagogical and curricular expertise; and LaGuardia's Registrar and Departments of Student Advising Services, Marketing and Communications, and Transfer Services for helping to make the transition to full scale as smooth as possible. Our thanks also to LaGuardia's Department of Institutional Research for providing us with data for repeated evaluations and course revisions, and during the drafting of this work, and to Maxine Roberts and Christopher Mullin for support and guidance throughout the article revision process.

About Strong Start to Finish

Right now, a first-year student sits in a college classroom being ill-served by remedial math.

And if we fail them, they mostly likely will not earn their degree. There is a persistent trend among students placed in remedial or developmental courses – particularly math and English. They are not completing the courses and, in most cases, should not be taking them in the first place. This should not be their path.

We are a network of like-minded individuals and organizations from the policy, research, and practice spaces who've come together for one reason – to help all students, not just the select few, find success in postsecondary education.

Strong Start to Finish was created to better the chances of low-income students, students of color and returning adult students, to create a fundamental shift in the outcome of their college journey. We have networked higher education leaders, policy entrepreneurs, institutions and technical assistance providers to drive towards an outcome where all students pass their first credit-bearing English and math courses during the first year of study.

Abstract

Primary Audience:

The primary, though not sole, audience for this publication is a department chair or faculty member within an institution.

Problem Statement:

Most of LaGuardia's students enter the college academically underprepared as determined by a system-wide placement test. From Fall 2013 to Fall 2017, 71% of entering students were placed into a remedial math course by this test, with a large disparity in achievement gaps among racial/ethnic groups. For this reason, developmental mathematics is seen as a gatekeeper particularly for students in traditionally disadvantaged groups.

Action:

Responding to a long-standing crisis in the math remediation approach, LaGuardia Community College brought transformative change to scale via the math co-requisite project. Designed to achieve the same learning objectives as their stand-alone college-level counterparts, our model uses a single course structure with extended instructional time, allowing for integrated just-in-time support for basic skills material.

Context:

Conditions which enabled the change included faculty readiness to embrace change, strong understanding of the problem, existing evidence of success of co-requisite courses, extensive support of college administration to process of change, and the existence of CUNY-wide structures to allow transfer of the new courses.

Process:

LaGuardia Community College math faculty developed and utilized a three-phase approach – Design, Pilot, then Permanently Implement – to redesign students' math experience. Mathematics sequence were reformed into a guided pathways sequence, where students initially placed at the level of elementary algebra have three paths to follow: (1) non-STEM path or Statistics co-requisite course, (2) STEM path or College Algebra co-requisite, (3) Fine Arts path or Quantitative Reasoning co-requisite.

Outcomes:

From Fall 2016 to Spring 2018, an average of 74% of students initially placed in Elementary Algebra, who chose the co-requisite path, completed their developmental math requirement and acquired college level credit in half the time compared to only 32% of students enrolled in the traditional path.

These positive effects are also seen when looking at different segments of the population, positively impacting students in the 18-24 age bracket with particularly high positive outcomes on students of non-traditional age. Traditionally marginalized groups like Hispanic and Black students are positively impacted with equivalent gains for all other racial/ethnic groups. Students who received a Pell grant at any point during their time at LaGuardia tend to perform equally or better in the co-requisite courses compared to the overall success rates of the co-requisite courses.

Sources of Support:

The sources that contributed to the success of this change include the technical assistance of the Carnegie Math Pathways to develop professional development programs on student-centered pedagogies and improvement, various grants including internal funds and Title V grants, and the communication and collaboration among many divisions across LaGuardia.

Introduction

In this paper we describe how LaGuardia Community College reformed its developmental mathematics offerings as a significant part of guided pathways transformation, reduced achievement gaps for students, and increased gateway completion, academic momentum, retention and graduation rates. Responding to a long-standing crisis in our math remediation approach, faculty brought transformative change to scale via the math co-requisite project. In what follows, we demonstrate how our math co-requisite models have been major drivers of student success for the college.

This paper is intended to share our experiences, by first setting the context, then providing practical guidance on the change process, followed by resulting outcomes of our work with a focus on equity and the sources of support to make this work happen, then closing with lessons learned and next steps. We hope to foster institutional change and inspire others who are planning their co-requisite transformational journey with our success story.

Context

Location & Student Population

LaGuardia Community College of the City University of New York (CUNY) is a gateway for thousands of ambitious college students – for the most part, immigrant, Hispanic, and low-income. Located in western Queens, NY, LaGuardia annually serves nearly 20,000 degree-seeking students and 80,000 continuing education students. Approximately 60% are foreign born, and half of those have lived in the U.S. fewer than five years. Eighty-seven percent are minorities (Hispanic: 49%, Asian: 22%, Black: 16%, Other: 1%), and many are the first in their family to attend college. In terms of financial resources, 60% of degree-seeking students receive financial aid grants including Pell grants, 57% of students live with parents in households with a family income of less than \$25,000 while 78% of students live away from parents and have income less than \$25,000. There is a wide range of ages in the degree-student population, with 53% of students falling in the traditional college age

range of 17 to 22. The median age has remained at 21 for the past 5 years (LaGuardia Community College Institutional Profile, 2018).

Most of LaGuardia's students enter the college academically underprepared as determined by a system-wide placement test. From Fall 2013 to Fall 2017, 71% of entering students were placed into a remedial math course by this test. Following a similar national trend (Bailey, Jeong, and Cho, 2010), Hispanic and Black students at LaGuardia are placed into developmental mathematics courses at higher rates than their peers.

Policy Factors

From Fall 2013 to Fall 2017 at LaGuardia Community College, an average of 71% of incoming students were placed in developmental math, with 61% of these students completing remediation in one semester and only 37% of students placed into the lower level courses completing remediation in one year. At best, students who place into developmental math face a long path to degree completion, and most are never able to earn the necessary math credits to complete their degree (Bailey, Jeong, & Cho, 2010). This crisis in mathematics remediation, which affects our college, led to widespread conversation and innovation around developmental mathematics reform.

The co-requisite mathematics initiative at LaGuardia Community College was inspired in part by the national conversation. Faculty from the Mathematics department, with the support of high-level academic officers, took the proactive approach to introduce change in our institution's policy and practice related to mathematics offerings with the aim of improving the academic outcomes for students.

Enabling Conditions

Several factors made LaGuardia Community College a hospitable environment for the development and implementation of co-requisite courses. These include a common understanding of the problem, the readiness of faculty to change, evidence of success

by peer colleges, a supportive administration, and its alignment with related initiatives.

A Common Understanding

There was a strong understanding within the Mathematics department and throughout the college that the model of mathematics remediation we were using was flawed and did not produce the outcomes we hoped to see for our students. This understanding, based on local and national data, created an environment in which faculty grew increasingly convinced that reforms were necessary.

Faculty Readiness

Faculty were ready to embrace change fostered by LaGuardia Community College's tradition of innovation and professional development. In particular, the history of departmental innovation in mathematics through contextualization (Project Quantum Leap, 2009), online learning, and the introduction of classroom technology, etc. supported largely by LaGuardia's Center for Teaching and Learning.

Evidence of External Success

The existence of additional data showing successful outcomes with co-requisite courses in mathematics elsewhere—for example, the initial success rates of the Carnegie Math Pathways courses (Grey, 2013), as well as a successful implementation of co-requisite courses in English at LaGuardia itself—made this model a natural choice.

A Supportive Administration

Administrators at LaGuardia Community College were and remain willing to provide financial and logistical support without interfering or influencing the curriculum design or implementation process, showing appropriate trust in the mathematics faculty to oversee the project entirely and setting the stage for close and collegial collaboration.

Alignment with Related Initiatives

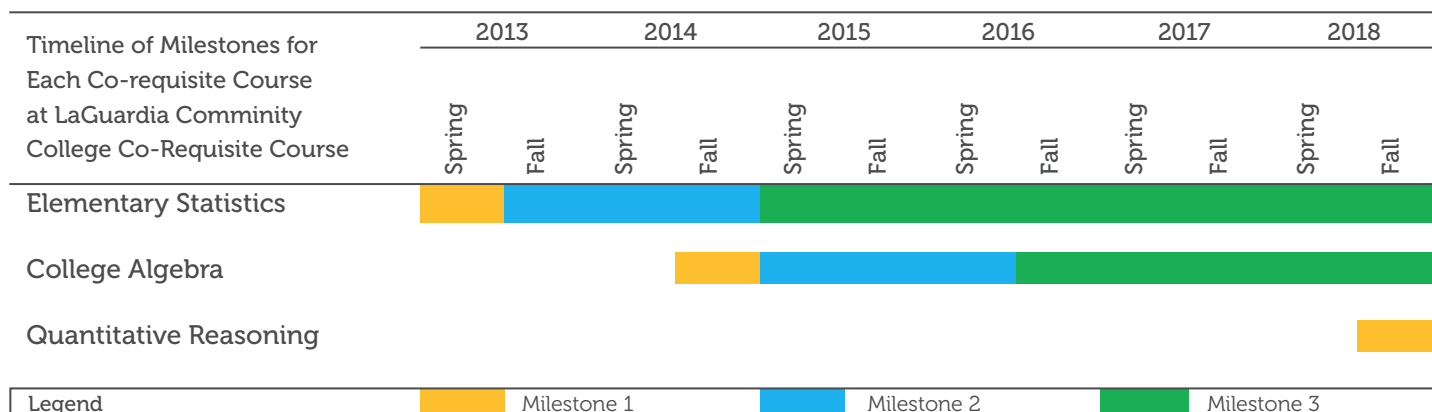
In Fall 2013, CUNY implemented the Pathways initiative across its undergraduate colleges. Pathways has established a new system of general education requirements and new transfer guidelines across the university ("CUNY Pathways" 2019). This initiative and related policies simplified and enabled the acceptance and transfer of our new co-requisite courses to other colleges within the CUNY system.

The Change Process

As of 2019, LaGuardia Community College offers two co-requisite courses with a third in development. These courses allow students placed in Elementary Algebra to satisfy their developmental mathematics requirements and earn college mathematics credits in a single semester. They are also designed to maintain their rigor by requiring students achieve the same learning objectives as their stand-alone college-level counterparts. Our model uses a single course structure with extended instructional time, allowing for integrated just-in-time support for basic skills material.

Our co-requisite Statistics with Elementary Algebra course (primarily for Liberal Arts majors commonly referred as non-STEM majors), which is equivalent to the traditional elementary algebra and college-level elementary statistics sequence, has been offered since Fall 2013. Co-requisite Algebra and Trigonometry course (for all STEM majors), which is equivalent to the traditional elementary algebra and college-level algebra sequence, has been offered since Spring 2015. Our final co-requisite course, in Quantitative Reasoning (primarily for Humanities and Fine Arts majors), is in development and will be piloted in Spring 2019.

FIGURE 1



MILESTONE EVENT 1

Design New Courses

This section outlines the multi-year process focused on the redesign of each of our co-requisite courses following the same three-phase timeline of implementation to scale (see Figure 1). During the single-semester design phase, we prepared curriculum and professional development activities for the initial pilot. The three-semester pilot phase began with a small pilot and then was brought to scale. The permanent improvement phase extends continuously following the pilot phase and involves an iterative process of continual assessment, maintenance, and development of the course. Following this timetable, full-scale implementation for each new co-requisite course was attained after two years. This section describes each phase in greater detail.

Identifying a Core Team

A core faculty design team was critical to setting a firm foundation. Each core co-requisite design

team consisted of motivated full-time tenure and tenure-track faculty, with both junior and senior faculty represented. Each team included members with significant curriculum development and design experience, and those familiar, via teaching or coordinating, with the traditional college-level course equivalent to the co-requisite model to be designed.

Revising the Curriculum

During the design phase, faculty identified the curriculum to be adapted for the new course. As faculty met to discuss the course design, they considered how college- and CUNY-wide governance aligned with course learning objectives and traditional college-level equivalents to ensure the new courses would meet transfer requirements within the CUNY system.

When implementing Statway during the design phase, we adopted the Carnegie Math Pathways (CMP) Statway curriculum and adapted it to a 12-week course. Statway is a set of statistical reasoning course curricula (1-2 term offering) designed to teach essential mathematics skills for a growing number

of occupations requiring decision-making under conditions of uncertainty. As such, Statway offerings are designed to meet a range of developmental and college-level student needs (“Statway,” 2019). In Spring 2013, Statway was only designed and offered as a year-long course. At LaGuardia, we decided to adapt Statway as a one-semester co-requisite course covering the same topics of the Elementary Statistics college-level course, while providing integrated support to develop the mathematics background skills required for students’ success in college-level statistics.

Our main design challenge was determining how to adapt Statway as a co-requisite course equivalent to traditional college-level Statistics and provide just-in-time support for developmental students. In other words, we needed to identify and select appropriate course materials to pair with Statway content that could cover the mathematics background skills developmental students need. Initially, during the design and pilot phase, a core group of faculty collaborated to select and identify the key Statway lessons to create a course equivalent to college-level Statistics. They used different sources that could support these students’ math-related needs, including Quantway lessons, the adaptive online learning platform [ALEKS](#), and [Khan Academy](#) courses. They also identified the mathematics background topics that developmental students need to succeed in college-level Statistics. We found that the prototyped curriculum—the selected Statway lessons and one of the basic skills sources—did not provide a cohesive experience for the students and instructors. Disparities between the Statway curriculum’s teaching styles, structures, and online platforms and those of basic skills resources encouraged instructors to develop and use faculty-created materials to achieve a cohesive curriculum that would support students’ math background needs.

A significant challenge in the Co-requisite Algebra and Trigonometry/STEM co-requisite course, was the identification and development of curricular materials that cover the college-level material while supporting the needs of students in developmental mathematics. Pre-calculus, algebra, and trigonometry textbooks do not review arithmetic to the extent necessary, and much of the basic skills algebra material is reviewed at the beginning of the text rather than integrated throughout

to support the college-level material. Furthermore, other levels of textbooks, such as elementary/intermediate algebra textbooks, do not cover the necessary college-level material. Customized textbooks, which combine multiple texts into a single volume, lacked coherence, not just in authorial voice but also in pagination and navigability. There were similar problems with the adaptive online learning platform (www.aleks.com) used for the first three years of the course. No pre-made online course covered the necessary material, and it was not possible to combine courses. It was also difficult to design a course that deviated from the order of existing textbooks. These curricular design difficulties persisted throughout the first five years of the course but were somewhat eased when the department moved to the open educational resources (OER) MyOpenMath/Lumen online platform. It is worth noting that the landscape of resources has changed since the initial development of the STEM co-requisite course; now many of the commercially available online learning platforms offer materials designed to support co-requisite courses.

Identifying Faculty Development Needs

To ensure they addressed factors that contribute to students’ success, faculty identified pedagogical modalities appropriate to each co-requisite course. They then designed and planned the faculty professional development required for launching the pilot phase.

The local implementation of Statway for our co-requisite course required the unique pedagogy and teaching modality of Statway, known as Productive Persistence. This pedagogy focuses on addressing students’ beliefs about themselves as mathematical learners and doers, and their feeling of belonging in a mathematical environment. It promotes collaborative learning and addresses socio-emotional factors that affect student success. Particularly, the Statway curriculum supports student mathematics learning, persistence, and engagement by using lessons that are challenging, relevant to students’ lives, and that promote development of flexible expertise. Productive Persistence promotes tenacity and good strategies to help students succeed when faced with challenges and to do so efficiently and effectively. Consequently, to offer this course at scale, we had to develop and implement a large scale and sustainable faculty professional development program to create a robust community of practice. In addition, for being part of the Carnegie Math Pathways network, faculty are invited to participate in Carnegie workshops in-person (during

the design and pilot phases) or online (permanent improvement phase). During these sessions, participants learned key components of the Statway curriculum, including lesson materials, class plans, and Productive Persistence pedagogical classroom strategies. Other types of professional development sessions are also offered periodically by faculty at LaGuardia to support teaching this co-requisite course.

MILESTONE EVENT 2

Pilot New Courses

The pilot phase took place over two to three semesters during which three primary tasks were accomplished. They include recruiting students for the new course, implementing and refining the curriculum, and implementing professional development for faculty.

Recruiting Students for the New Course

During the pilot phase, other departments and divisions of the college began to come together to support the new course. Student and Academic Affairs closely collaborated to ensure the success of LaGuardia's co-remediation initiative through highlighting the new courses and their benefits for the entire student population. This collaboration included training advisors and promoting the co-requisite courses in various college advising structures, such as First-Year Seminar (FYS) and the new advisement model (Advisement 2.0). Furthermore, the new co-requisite courses were integrated into curriculum maps, an academic momentum campaign where students are advised to register into courses to complete 30 credits in their first two terms, in addition to sharing the initiative outcomes with the college community via college-wide events and meetings.

Scheduling the new co-requisite courses revealed another dimension of close collaboration between the Student and Academic Affairs Divisions. Numerous meetings between the Mathematics Chairperson and the Registrar took place to address the scheduling of additional co-requisite hours, severe classroom space limitations, and heightened demand associated with prime-time course schedules, e.g. sections running between 10:30 am

to 2:00 pm. This was supported by the registrar, who assured that the co-requisite course would be counted as equivalent to the traditional sequence.

Implementing and Refining the Curriculum

Faculty collaboratively implementing and refining the curriculum were focused on better aligning developmental education and college-level course learning outcomes. To address the challenges related to the transfer of co-requisite courses to CUNY's four-year institutions, we assessed whether the learning goals of the Elementary Statistics course were achieved by subjecting students enrolled in the co-requisite Statistics course to the same departmental final exam as their peers in the traditional Elementary Statistics course and conducting double-blind grading. As a result of this study, we found no significant statistical difference of students' performance in the final exam between the two groups of students. Furthermore, we were not able to identify students' initial math placement based on their Statistics final exam performance. These results were presented and shared to chairs in CUNY math departments and resulted in the acceptance of this course to be transferred in the CUNY-wide system as an Elementary Statistics course.

After completing the curricular governance process, new courses were accepted to become a permanent part of the college and university-wide curriculum. Moreover, we engaged in an aggressive transfer support campaign to ensure transfer within CUNY by explaining the new co-requisite course models and describing how they achieve the same learning outcomes as traditional stand-alone courses; such an effort required advocacy, persistence, and longitudinal tracking across CUNY.

Implementing Professional Development for Faculty

A core group of about three faculty identified professional development needed to support faculty praxis as the co-requisite course launched at scale. The supports included faculty-peer mentorship, workshops, and seminars focused on alternative pedagogical modalities and understanding the needs of the students placed at the elementary algebra level. The Center for Teaching and Learning supported

planning/design of faculty professional development, particularly during the full-scale launch term.

MILESTONE EVENT 3

Permanent Improvement Phase

Working at Scale

Once at full scale, the co-requisite course became permanent and equivalent to the traditional sequence of courses it replaced. As the number of faculty teaching the co-requisite course increased, more opportunities for curricular fine-tuning and alignment developed. An example was the identification of remedial mathematics skills students need to master college-level material. During the first semesters of the permanent improvement phase, effective communication among the different divisions of the college was imperative to sustain guided pathways reform.

Refining our Understanding

The permanent improvement phase is also the most appropriate time for redesigning learning outcomes assessments. These data, and other data, allowed us to analyze the impact of the co-requisite course on completion, retention, and graduation rates because of the statistical significance of the size of the data sample.

Ongoing Professional Development

To support faculty at LaGuardia Community College during the permanent improvement phase, we implemented a robust ongoing professional development program to create a community of practice, in which faculty mentors and co-requisite course instructors discuss curriculum, technology, pedagogy, and college policies, make curricular adjustments as necessary, and develop resources to share with other stakeholders, including advisors, administrators, and tutors. These sessions were

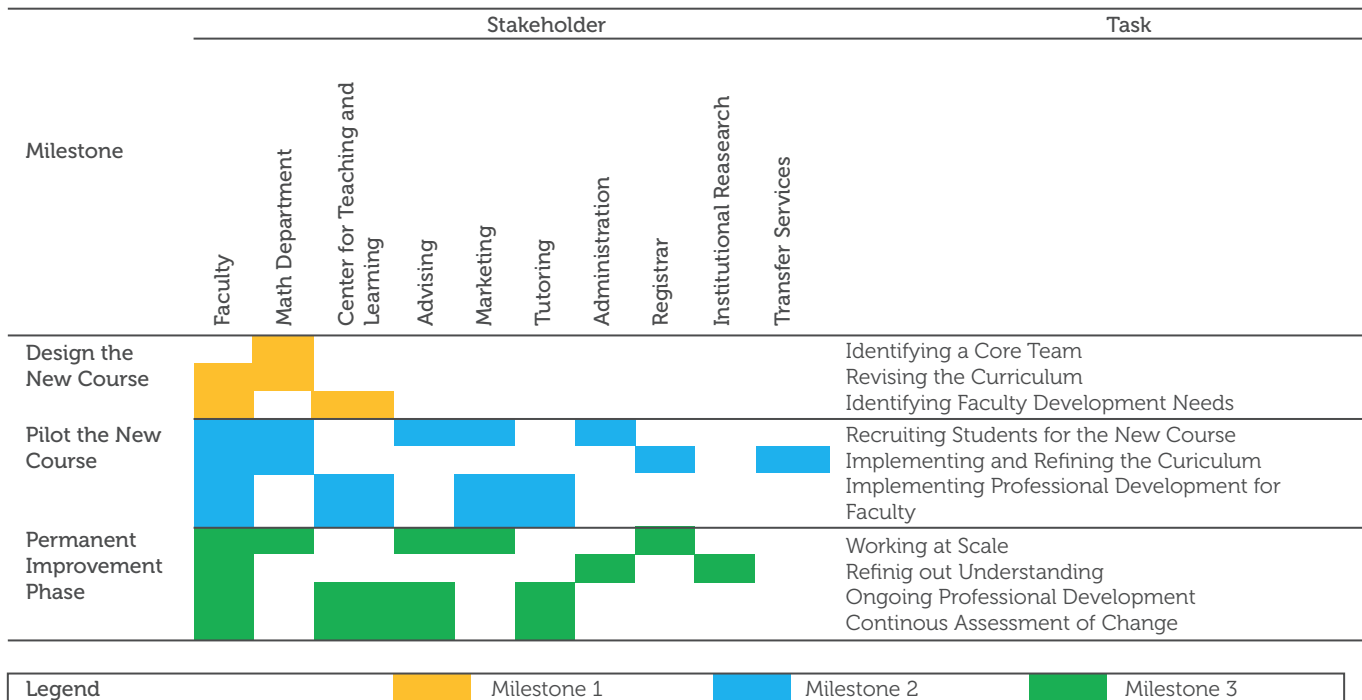
conducted in collaboration with our co-requisite faculty leaders and the Center for Teaching and Learning (CTL) and include full- and half-year seminars and multi-day workshops focused on pedagogical modalities, effective use of the management platform, and careful tracking of student engagement. Faculty are assigned reading materials and asked to contribute to discussion boards, and numerous open faculty forums are scheduled throughout the year. During the permanent phase, we increased the size of the faculty to develop a community of practice to help refine, assess, and continually improve implementation of curricula.

In general, during the pilot and permanent improvement phases, one of the key important factors for success of this initiative was that faculty met to pilot, assess, experiment, converse, and debate, and to adjust each co-requisite course accordingly. This group included both full-time and part-time faculty, as well as those with strong curriculum design experience and successful textbook writing backgrounds. We also ensured that this group included faculty who approached the co-requisite initiative with varying degrees of skepticism, leading to a great deal of productive disagreement. The goals for all faculty involved were to design co-requisite model courses that achieved the same learning objectives as their stand-alone counterparts and were transferable within the CUNY system.

In sum, early in the change process we learned that success of a large-scale initiative such as this requires the expertise of the whole college. Figure 2 lists the milestone events and the tasks associated with the implementation of these co-requisite courses undertaken by a wide range of LaGuardia's stakeholders.

FIGURE 2

Stakeholder Roles and Tasks During Each Milestone Event at LaGuardia Community College.



Outcomes from Change in Practice

Overall Changes

As of 2019, LaGuardia Community College offers two co-requisite courses with a third in development. These courses allow students placed in Elementary Algebra to satisfy their developmental mathematics requirements and earn college mathematics credits in a single semester. They are also designed to maintain their rigor by requiring students to achieve the same learning objectives as their stand-alone college-level counterparts. Our model uses a single

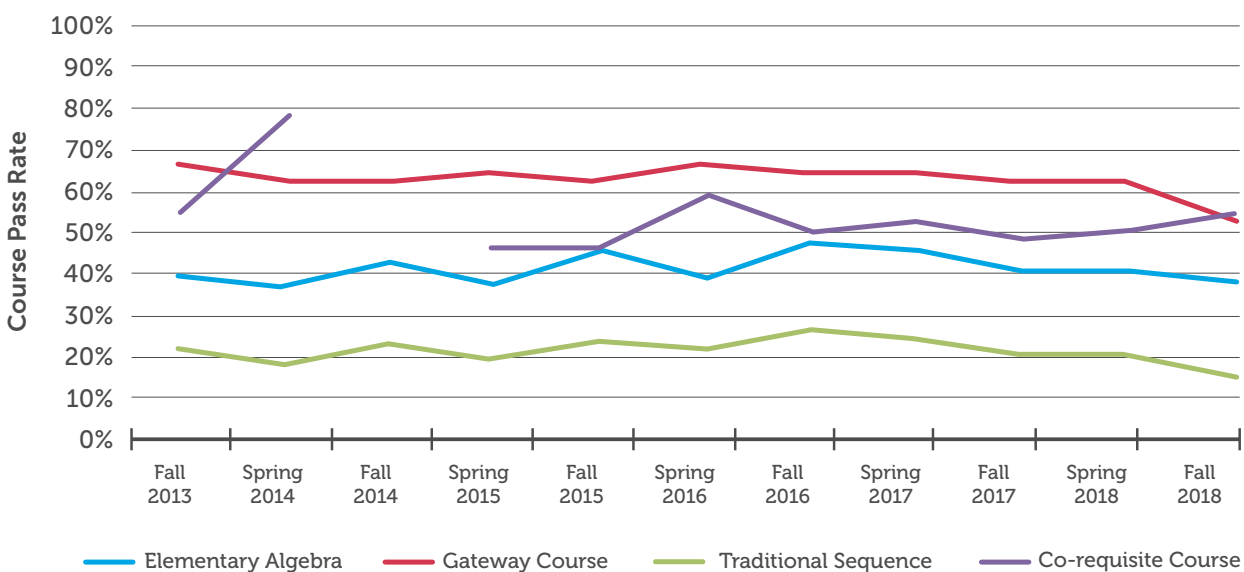
course structure with extended instructional time, allowing for integrated just-in-time support in which developmental knowledge and skills are introduced when needed to support learning of college level material for basic skills material.

Our co-requisite Statistics with Elementary Algebra course (primarily for Liberal Arts majors commonly referred as non-STEM majors), which is equivalent to the traditional elementary algebra and college-level elementary statistics sequence, has been offered since Fall 2013. Co-requisite Algebra and Trigonometry course (for all STEM majors), which is equivalent to the traditional elementary algebra and college-level algebra sequence, has been offered since Spring 2015. Our final co-requisite course, in Quantitative Reasoning (primarily for Humanities and Fine Arts majors), is in development and will be piloted in Spring 2019.

Compared to the course completion rates of the traditional sequence, the introduction of two co-requisite courses significantly improved the one-year college-level math course completion rate for students placed at the elementary algebra level (a developmental education course). For example, as shown in Figure 3, over the period between Fall 2013 and Fall 2018, 56% of the students placed in Elementary Algebra who chose the corequisite path (purple line), successfully completed, with a grade of C or higher, their developmental math requirement and acquired entry-level college credit in half the time—compared to only 29% of the same placement students (green line) who successfully completed the traditional sequence of two courses in at least a year, or the compound traditional success rate of being

successful first in Elementary Algebra course (blue line) and their first level gateway course (orange line). This change represents an average of 27 percentage points in the success rates of students placed at the elementary algebra level. This difference can be seen as the distance between the green and red lines in Figure 3. Despite improvement of the one-year college-level math course completion rates by the introduction of one-semester corequisite courses, success rates of the gateway courses are on average about 8 percentage points higher than the corequisite success rates (distance between the red and purple lines). But this gap is decreasing as the implementation of the co-requisites at a scale is sustained.

FIGURE 3
Course Pass Rates, by Course Type: Fall 2013 to Fall 2018



Source: Authors' analysis of course data as submitted to CUNYFirst and reported by LaGuardia's IR Office.

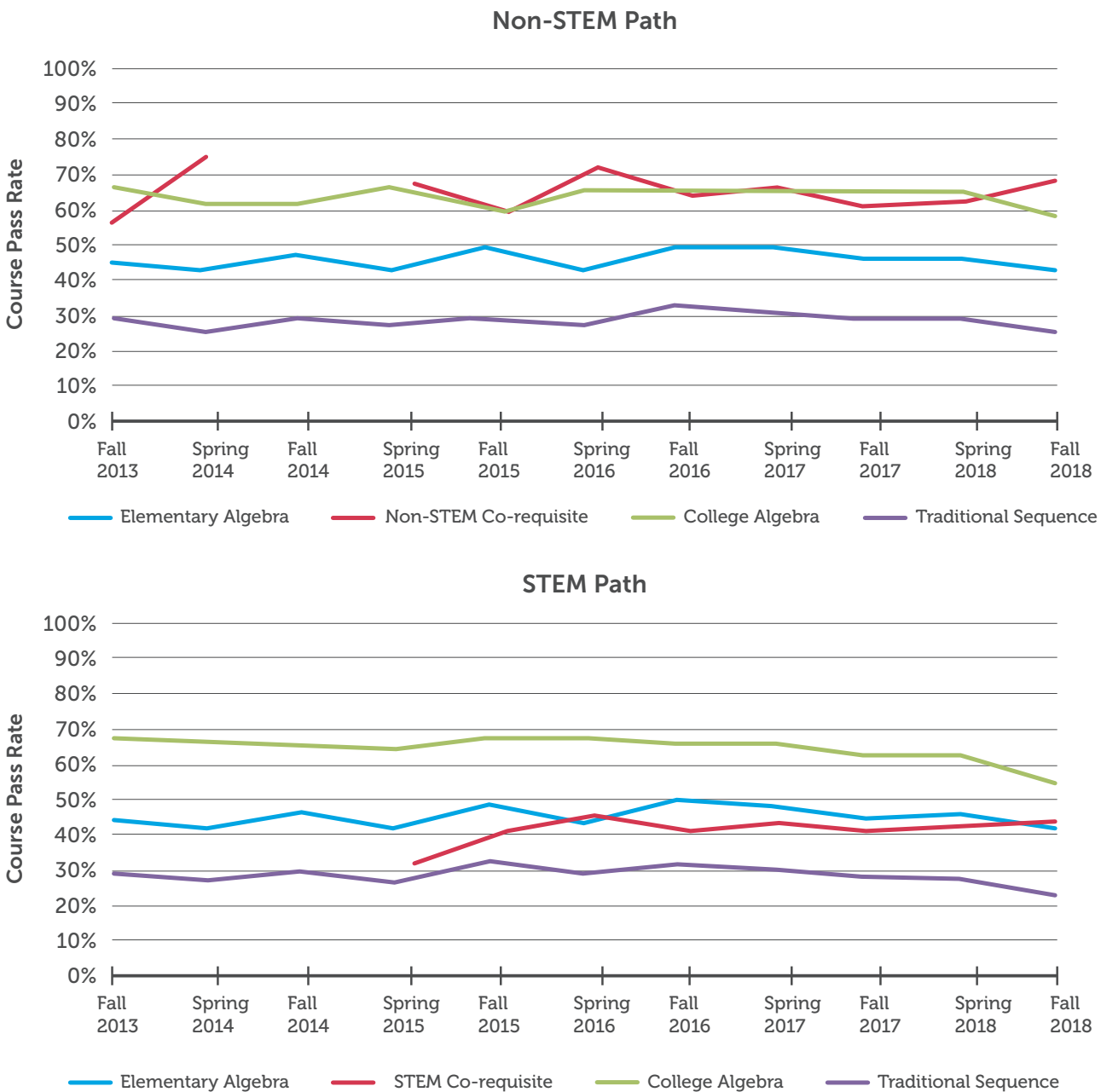
Notes: Overall pass rates for the co-requisite courses over the period of the intervention. Pass rates include C or higher grades and includes in the total for calculation, withdrawals counted as failing grades. A co-requisite course is equivalent to a traditional sequence of Elementary Algebra and a Gateway course thus the Traditional Sequence Overall Pass Rate is the estimation of a student passing the sequence of courses composed by Elementary Algebra and then a Gateway course. This is calculated as the corresponding pass rates at a given term.

In Figure 4, we present the course completion rates for students in each of the two co-requisite courses implemented at scale and compare these with completion rates for the equivalent traditional sequence. In examining the Elementary Statistics (non-STEM) and the College Algebra (STEM) pathways in Figure 4, we see that in the former (using a one-term Statway implementation) an average increase of 30 percentage points was seen in the one-year college-

level math completion rate, doubling the success rate of the traditional sequence. Similarly, the College Algebra (STEM) co-requisite pathway has increased the one-year college level math completion rate by an average of 13 percentage points. In both cases, the improvements in success rates have been maintained at scale, helping students keep academic momentum and earn two-year college degrees faster.

FIGURE 4

Course Pass Rates for Non-Stem and STEM Paths, by Course Type: Fall 2013 to Fall 2018



Source: Authors' analysis of course data as submitted to CUNYFirst and reported by LaGuardia's IR Office.

Notes: Pass rates for the co-requisite courses over the period of the intervention. Pass rates include C or higher grades and includes in the total for calculation, withdrawals counted as failing grades. A co-requisite course is equivalent to a traditional sequence of Elementary Algebra and a Gateway course thus the Traditional Sequence Overall Pass Rate is the estimation of a student passing the sequence of courses composed by Elementary Algebra and then a Gateway course. This is calculated as the corresponding pass rates at a given term.

each of the co-requisite courses is presented in Table 1. This plot shows that both non-STEM and STEM co-requisites positively impact first-time students in the 18-24 age bracket since this is the most represented age group enrolled in co-requisite courses. The figure below clearly shows that students of all ages are positively impacted from taking these courses and acquired college-level math faster and at higher rates. It also shows that as the students' age increases, the passing rates do too. Older students tend to have higher success rates than the average passing rates. This effect is seen across both co-requisite courses.

Equity-focused Change

For the equity-focused analysis, we narrow our data to students enrolled for the first time only in the co-requisite courses and the elementary algebra course from Spring 2015 to Fall 2018.

The age distribution of the successful students in

TABLE 1
Course Pass Rates by Age, Race/Ethnicity and Pell Status in Non-STEM and STEM Co-Requisite Courses: Spring 2015 to Fall 2018

Age Group	Non-STEM Co-Requisite Course															
	Pass Rate (%)															
	S15		F15		S16		F16		S17		F17		S18		F18	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Under 18	1	100	-	-	-	-	-	-	-	-	1	100	-	-	-	-
18 to 24	77	64	361	54	332	71	296	60	186	60	217	57	110	59	60	60
25 to 31	35	69	131	67	120	74	154	67	107	70	92	74	55	64	61	79
32 to 38	14	100	43	70	41	71	44	68	28	79	14	50	9	100	9	67
39 to 45	5	80	10	30	14	64	12	58	10	90	5	60	2	50	6	50
45 to 53	3	0	6	67	9	89	9	78	1	100	5	20	2	0	4	50
Over 53	1	0	4	50	2	50	-	-	3	67	3	33	1	0	1	0
Overall	136	68	555	58	518	58	515	63	335	66	337	61	179	61	141	67

Race/Ethnicity	N	%	N	%	N	%	N	%	N	%	N	%	N	%		
Hispanic	66	67	279	62	256	72	271	64	165	69	194	61	95	57	63	67
Black	41	71	155	45	150	67	127	57	92	63	82	56	48	63	24	67
White	17	71	64	69	54	76	51	65	23	83	24	67	16	81	15	73
Asian	12	58	54	65	58	79	63	73	37	51	32	69	12	75	8	75
Other	-	-	3	33	-	-	2	50	18	56	5	40	4	25	31	64
Overall	136	68	555	58	518	58	515	63	335	66	337	61	179	61	141	67

Financial Aid	N	%	N	%	N	%	N	%	N	%	N	%	N	%		
With Aid	119	70	440	60	427	74	428	63	285	66	296	61	95	60	75	73
Overall	136	68	555	58	518	58	515	63	335	66	337	61	179	61	141	67

Source: Authors' analysis of course data reported by LaGuardia's IR Office.

Note: Data only for first-time taker students pass rates from Spring 2015 to Fall 2018. Pass rates include C and higher grade, with withdrawals counted as failed grades. Data reflect first-time taker students enrolled in the co-requisite courses for non-STEM (left) and STEM (right) pathways. Financial Aid counts students who received any kind of financial support, including Pell Grants, for a given term.

Table 1 also presents the passing rates of a given ethnicity group between Spring 2015 and Fall 2018 for each co-requisite course. In general, co-requisite course benefits populations that traditionally are misrepresented and deemed more frequently as not-college ready, as it is the case for Hispanic and Black first-time-taker students, as these courses enrolled a majority of Hispanic (47%) and Black (21%) students, similar to our institutional profile.

In the case of the non-STEM co-requisite course, all ethnic groups succeeded equally in this course. Hispanic and Black students succeed on average over this period at higher rates, 86% and 87%, respectively, than the overall success rate of 82%. This shows that the introduction of this new course highly impacted these groups of students. In the case of the success rates in the STEM co-requisite course, on average over this period, Asian and Black student groups succeeded equally in this course, Hispanic students succeeded at lower rates (63%), and White students perform higher than the overall success rate, 78% versus 67%, respectively.

It is also important to note that the STEM co-requisite course presents higher variability in pass rates by racial/ethnicity group versus the non-STEM co-requisite course arguably due to the higher volume of emotional and cognitive pedagogical components immersed in the [Carnegie Math Pathways](#) curriculum. Lastly, Table 1 shows the positive impact on first-time taker students receiving a Pell grant during their enrollment at LaGuardia for the period shown. Success rates for these students is equal to or higher than the overall success rates during the period between Spring 2015 to Fall 2018. This provides evidence that students with Pell grant status succeed at the same rate as students who do not qualify for Pell.

In summary, creating a math pathway for 60% of students initially placed in elementary algebra has positively impacted students in the 18-24 age bracket, with a particularly high positive impact on students of non-traditional age. Traditionally marginalized groups like Hispanic and Black students are positively impacted with equivalent gains across other subgroups, with impressive reduction of the achievement gap across subgroups enrolled in the non-STEM co-requisite course. Students who received a Pell grant at any point during their time at LaGuardia tended to perform

equally or better in the co-requisite courses as any other students enrolled during the same period in the same co-requisite course. These conclusions are conservative given the nature of our sample: first-time taker students enrolled in co-requisite courses from Spring 2015 to Fall 2018. As we continue to study the efficacy of the co-requisite courses, we are paying particular attention to various gains for students in alternate pathways to achieve college credit, success in subsequent courses are being studied to analyze the effect on their academic momentum, and retention and graduation rates. Detailed results of this post-participation study will be presented elsewhere in the near future.

Sources of Support

Technical Assistance Support

LaGuardia has been a member of the Carnegie improvement network since January 2013. This network has created and implemented the Carnegie Math Pathways in over 60 institutions nationwide. It is composed of math faculty, educational researchers, and designated experts, enabling a community of practice focused on the needs of students, and continuously assessing and refining results to make sure that positive change occurs. For the implementation of a one-term Statway co-requisite course starting Fall 2013, LaGuardia's core faculty collaborated with experts from Carnegie's Networked Improvement Communities to design a robust professional development experience for future Statway instructors. This experience familiarized participants with the pedagogical components of the Statway curriculum, such as productive persistence and language and literacy supports. The professional development program developed at LaGuardia, in collaboration with Carnegie staff, was used as a template to create professional development programs designed for the implementation and scale-up of the subsequent College pathway, the STEM co-requisite course.

Grant Support

Funding was key to the co-requisite initiative. The college's Academic Affairs division provided the math department with initial funding, but LaGuardia's Provost quickly realized that this outlay would not be adequate to affect change at the necessary scale. Consequently, the Associate Provost for Academic Affairs convened a college-wide team, which included the Mathematics chairperson, to seek external funding. This group successfully secured two Title V grants totaling \$6M to support the new math co-requisite project, along with other college-wide projects.

Moving Forward

Lessons Learned

LaGuardia's mathematics co-remediation initiative has been a long journey filled with challenges and opportunities. Early in the process, we learned that success of a large-scale initiative such as this requires the expertise of the whole college, and that it is important to offer spaces where faculty can engage in honest dialogue about the project and its future. We also found that sustainability of the initiative needs to be a key consideration, requiring financial support, and a willingness to continually assess and improve beyond the pilot phase.

College-wide Collaboration

Strong administrative leadership and cooperation from the Provost and Mathematics Chairperson were critical for the success of the co-requisite initiative. Collaborative efforts from LaGuardia shareholders, including faculty, administration, Center for Teaching and Learning, and Student Affairs professionals in advising, transfer, and marketing also contributed to the project's success. As such, the initiative's success demonstrates that reform requires support and cooperation from individuals within multiple departments in an institution. These collaborations have also resulted in greater alignment between

Academic Affairs and Student Affairs and created opportunities for cross-divisional collaboration with a common goal. For example, the mathematics co-requisite project led to the creation of the LaGuardia Developmental Education Council, which is comprised of faculty, representatives from student support initiatives, and Student Affairs staff. The council is charged with integrating co-requisite model courses into the overall strategic plan and long-term goals of the college.

The Importance of Welcoming Collaboration and Dissent

It is tempting to leave the development of co-requisite courses (or any initiative) to those with full faith in the project, however, LaGuardia's co-requisite design process benefitted strongly from the inclusion of faculty who had varying degrees of skepticism. While conversations among faculty with different degrees of faith in the project could be difficult at times, the development of curricula was richer for it, as was the experience and overall effect of professional development. It is valuable to allow dissenting faculty space to share their thoughts and expertise freely, particularly when the initiative is designed to be long term and large scale.

The Need for Financial Sustainability

LaGuardia's co-requisite mathematics initiative has benefited from significant financial support, including funds from two Title V grants and CUNY's Strong Start to Finish grant. This money has been necessary to fund ongoing curricular and professional development, providing funding for design teams and professional development participants, as well as support for travel so that co-requisite teams could exchange expertise with colleagues on a regional and national level.

Continuous Improvement Through Assessment

As we continue to offer the co-requisite courses with an eye to making them ever-stronger, we have found that being aware of the data, remaining open to adjusting the curriculum, and offering faculty development are paramount. The initial design and pilot of these courses may be a one- or two-year process, but meaningful data takes longer to accrue, and we continue to compile and adjust according to what the ongoing data reveals. In addition, it has been necessary to edit course curricula

semester-to-semester, even after the pilot phase, from small tweaks to full redesign in response to the experience delivering these courses and the continuous assessment of the outcomes of the initiative. We have also found that faculty development beyond the initial pilot phase is necessary, allowing us to train new faculty in content and pedagogy, create a forum for experienced faculty to reflect on these materials, and provide ongoing support for course evaluation and development.

Next Steps

The next four steps for our college's work in co-requisite implementation are: integrating the three co-requisite courses into clear guided pathways in mathematics, replacing traditional textbooks and commercial online learning systems with OER, designing sustainable professional development for co-requisite faculty to familiarize them with student-centered classroom strategies and experience-based/contextualized classroom activities, and continuing data analysis. We believe that these endeavors will make mathematics more accessible and improve degree-completion rates for LaGuardia students, maintain faculty engagement with the community of practice established in professional development, and give us deeper insight into the impact of LaGuardia's co-requisite mathematics initiative.

Integration into Guided Pathways

LaGuardia Community College faculty are developing a guided pathways approach that uses highly-structured, educationally-coherent degree maps. These visual representations describe how every undergraduate major can be completed in two years, depending on placement. The maps support individualized student advisement and the course planning requirements of academic departments. At LaGuardia, we are working toward the establishment of three guided pathways: one for majors requiring statistics, a second for majors needing quantitative reasoning, and a third for STEM majors requiring significant algebra preparation. One of the main goals of LaGuardia's guided pathways is to identify the student populations appropriate for each of our college-level and co-requisite courses so that students have a clearer path to degree completion.

LaGuardia's OER Initiative

The Mathematics department is currently undertaking an initiative to replace high-cost commercial curricular materials with free/low cost open educational resources (OERs). As of this writing, we have redesigned 5 courses, including the co-requisite algebra and trigonometry course, to use OER text, video, and online learning platforms (Lumen/MyOpenMath). In addition, team leaders for the Elementary Statistics pathway are working with Carnegie Math Pathways personnel to reduce the cost of co-requisite course materials. Our OER project is projected to save our students \$1.2M in textbook costs yearly. As with the initial co-requisite initiative, the OER project requires significant resources for design and professional development. It also requires institutional cooperation, particularly with library experts in research and copyright.

Sustainable Professional Development

Co-requisite faculty leaders are implementing innovative classroom strategies and professional development using the Statway curriculum and improvement science (Bennet & Provost, 2015; Bryk et al., 2010) to increase student engagement and outcomes and to enhance faculty's teaching and classroom managing skills. A new cycle of professional development is also being offered to faculty who have taught the co-requisite model previously, which seeks to refresh (or boost) their pedagogical skills and their understanding of the curricular components of the co-requisite courses. These sessions also provide support for new faculty assigned to teach this course and a chance to integrate and interact with experienced faculty teaching the course. Overall, it is designed to create a community of practice that continuously supports faculty throughout the term, offers opportunities to reflect on their experience with co-requisite courses, and consider future pedagogical and curricular directions for existing courses. Professional development for the new quantitative reasoning co-requisite course, targeting students with upper level remedial (elementary algebra) needs and in Fine Arts majors, is in the planning stages.

Continued Assessment and Data Analysis

An analysis of the impact on students who have participated in the new guided pathways is in progress. We are using data to assess the net impact on student course completion, graduation and transfer rates, and evaluating performance rates in subsequent courses. This collaborative project involves Mathematics faculty and LaGuardia Community College's Institutional Research Office. Results of this study will be published in the near future.

References

Bailey, T., 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.

Barnett, E.A., Bergman, P., Elizabeth, K., Reddy, V., Belfield, C.R., & Roy, S. (2018) Multiple measures placement using data analytics: An implementation and early impacts report (CARP Publications). New York, NY: Center for the Analysis of Postsecondary Readiness, Teachers College, Columbia University. Retrieved from <https://postsecondaryreadiness.org/multiple-measures-placement-using-data-analytics/>

Belfield, C.R., & Crosta, P. M. (2012). Predicting success in college: The importance of placement tests and high school transcripts (CCRC Working Paper No. 42). New York, NY: Columbia University, Teachers College, Community College Research Center. Retrieved from <http://ccrc.tc.columbia.edu/publications/predicting-success-placement-tests-transcripts.html>

Bennet, B., & Provost, L. (2015) What is your theory? Quality progress: The official publication of the American Society for Quality (ASQ). Milwaukee, WI. Retrieved from <http://asq.org/quality-progress/2015/07/continuous-improvement/whats-your-theory.html>

Bryk A. S., Gomez, L. M., & Grunow A. (2010) Getting ideas into action: Building networked improvement communities in education (Essay). Stanford, CA: Carnegie Foundation for the Advancement of Teaching. Retrieved from <http://www.carnegiefoundation.org/spotlight/webinar-bryk-gomez-building-networkedimprovement-communities-in-education>

Clyburn, G. M. (2013). Improving the American Dream: Mathematics pathways to student success. *Change: The Magazine of Higher Learning*, 45:5, pp. 15-23.

CUNY Pathways (June 18, 2019) Retrieved from <https://www2.cuny.edu/about/administration/offices/undergraduate-studies/pathways/>

LaGuardia Community College Office of Institutional Research and Advancement. 2018 Institutional Profile. Retrieved from https://www.laguardia.edu/uploadedFiles/Main_Site/Content/IT/2018-Institutional-Profile.pdf

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, U.K.: Cambridge University Press

Center for Teaching and Learning, LaGuardia Community College. (2009). Project Quantum Leap (PQL) sampler: Contextualizing the basic skill mathematics at LaGuardia Community College. Retrieved from https://www.laguardia.edu/uploadedFiles/Main_Site/Content/Academics/Departments/MEC/Doc/Faculty_Resources/pql_sampler_webVersion.pdf

Scott-Clayton, J. (2012). Do high-stakes placement exams predict college success? (CCRC Working Paper No. 41). New York, NY: Columbia University, Teachers College, Community College Research Center. Retrieved from <http://ccrc.tc.columbia.edu/media/k2/attachments/high-stakes-predict-success.pdf>

Statway. (February 8, 2019) Retrieved from <https://www.carnegiemathpathways.org/statway/>

Appendix A:

Site Context

What is the name of the institution(s), and if appropriate system, where the changes in practice took place?

LaGuardia Community College. City University of New York.

In which state(s) is/are your institution/system located?

Long Island City, New York State.

At which type of institution(s) did this change in practice take place?

2-year public.

What is the total, undergraduate (headcount) enrollment for the institution where the change in practice took place?

LaGuardia Community College credit enrollment is of 19,356 students with an annual non-credit enrollment of 79,323 students.

What percentage of full-time, beginning undergraduate students received a Pell Grant?

A total of 60% of the students receive some form of financial aid, including Pell grants.

What percentage of students are African American/Black?

17%

What percentage of students are American Indian/Alaskan Native?

Less than 1%

What percentage of students are Asian/Pacific Islander?

Less than 1%

What percentage of students are Hispanic or Latinx?

49%

What percentage of students are More than One Race?

N/A

What percentage of students are White?

11%

What percentage of students are aged 24 or under?

71%

What percentage of students are aged 25 or older?

29%