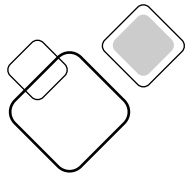

Mentoring Faculty Through a Quantitative Reasoning Professional Development Program: Why Do Faculty Participate and What Do They Get Out of It?

ESTHER ISABELLE WILDER

ABSTRACT | Although quantitative reasoning (QR) is central to general education, many college students lack fundamental numeracy skills. In response, The City University of New York established a QR faculty development program that trained instructors across the disciplines through teaching exercises, guided discussions, hands-on activities, the development of instructional/assessment materials, and feedback from mentors and peers. Ten cohorts, 2010–2019, responded to surveys that evaluated their motives for participating and the extent to which they felt their goals were met. Faculty joined the program due to factors including their concern for students, their commitment to QR instruction, and their desire to build professional networks. Program completers reported a better understanding of QR, a greater commitment to QR instruction, increased awareness of tools and techniques (e.g., progressive pedagogies, active learning and constructivist approaches), a clearer sense of students' needs, a commitment to assessment, and strong engagement with CUNY's multidisciplinary, multi-institutional QR community. Overall, the perceived benefits of the program match participants' motives for joining. Respondents' comments suggest that faculty development for general education requires motivated participants, opportunities for networking, thoughtful discussion of readings and videos, modeling of best practices, a student-centered curriculum, sensitivity to participants' backgrounds, adequate incentives, effective mentorship, and institutional commitment.

KEYWORDS | active learning, mentoring, multidisciplinary instruction, numeracy, quantitative literacy

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Quantitative Reasoning (QR), also known as quantitative literacy (QL) or numeracy, is increasingly recognized as an essential skill for college graduates. As reported by the Association of American Colleges and Universities (AAC&U), "many of today's students will need a wide range of high level quantitative skills to complete their work responsibilities. And virtually all of today's students, regardless of career choice, will need basic QL skills like the ability to draw information from charts, graphs, and geometric figures, and the ability to accurately complete straightforward estimations and calculations" (2009, p. 1). Elrod (2014) calls quantitative reasoning the "next 'across the curriculum' movement," noting that many universities are developing general education learning goals that focus on QR skills. QR is an Essential Learning Outcomes of the AAC&U, an important component of the Lumina Foundation's Degree Qualification Profile, and a core competency recognized by regional accreditation agencies (Elrod, 2014).

Faculty development programs must prepare instructors to respond to the QR challenge (Nuhfer, 2015). The more successful programs provide instruction in best practices within a supportive environment, infusing QR into multidisciplinary initiatives such as service learning. Many are explicitly modeled on general education programs in other areas such as writing across the curriculum (Madison & Steen, 2008; McLeod & Soven, 2000; Surak & Pope, 2016). Faculty development initiatives that focus on integrative learning require a sustained effort to build "skills, commitment, and community" (Bloss et al., 2010), since they must often overcome faculty resistance rooted in distrust, fears of evaluation, and inadequate time and rewards (Koerin, 1980).

Recent QR faculty development programs have varied considerably in their methods. Some have emphasized specific skills such as spreadsheets (Vacher & Lardner, 2010) while others have blended writing and QR (Grawe & Rutz, 2009). Still others have encouraged faculty in all areas to develop instructional modules that teach traditional subject content as well as QR (Hillyard et al., 2010; Steele & Kiliç-Bahi, 2008). Lardner and Bookman (2013) have stressed the need to cover foundational topics such as learning goals and assessment, to recognize the importance of the faculty's content knowledge, to avoid a narrow focus on software, and to provide examples and templates whenever possible.

Research has shown conclusively that faculty development programs can improve teachers' effectiveness and students' learning (Cox, 2013; Gibbs & Coffee, 2004; McLean et al., 2008). Several authors have identified the common characteristics of successful programs: multidisciplinary participation, multi-campus involvement, sensitivity to differences in initial preparedness, opportunities for open discussion of teaching methods and experiences, explicit coverage of techniques for assigning and evaluating students' work, strong mentorship, the integration of instruction and assessment, faculty ownership of the

assessment process, and a sense of community that persists after the completion of the program (Carpenter & Fitzmaurice, 2018; Laughlin, 1997; McLeod & Soven, 2000; Steinert, 2010). Other key elements of successful programs include the recruitment of enthusiastic participants; collaboration, peer support, and networking; a focus on students; the production and assessment of deliverables that can be used in teaching; and an institutional climate that values and rewards faculty development (Campbell et al., 2019; Proctor et al., 2020).

This article draws on survey questions and open-ended comments to identify the motives and experiences of participants in a multidisciplinary QR faculty development program sponsored by the City University of New York (CUNY)[1] and supported by the National Science Foundation (NSF). The study focuses on the reactions of participating faculty—their satisfaction with the program—but it also touches on three other components of evaluation identified by Kirkpatrick (1994): demonstrated learning (knowledge, skills, and attitudes), changes in behavior (such as the adoption of new teaching methods), and results (broader impacts on students and on the organization). Although the CUNY programs have been shown to improve students' QR performance and attitudes (Wilder, 2009, 2010; Wilder et al., 2021), the emphasis here is on the goals and perceptions of the participating faculty.

Infusing QR Across the Curriculum

Although QR—the contextualized use of numbers and data in ways that involve critical thinking—rests on a solid mathematical foundation, it requires more than mathematical or statistical fluency (Madison, 2004, pp. 4–5; Madison & Dingman, 2010). Activities such as reading graphical displays, modeling real-world phenomena, solving practical problems through the use of data, justifying conclusions, and critiquing research designs all require good QR skills (AAC&U, 2009; Johnson & Kaplan, 2008; Shavelson, 2008). A multidisciplinary, active learning approach to QR instruction is therefore essential (Bressoud, 2009; Gillman, 2006; Maass et al., 2019; Madison, 2009). As Ganter (2006, p. 13) has pointed out, "QL must be everywhere in the curriculum, in all disciplines and all courses." "Like learning to write well or speaking a foreign language, numeracy is not something mastered in a single course. . . . Thus quantitative material needs to permeate the curriculum, not only in the sciences but also in the social sciences and, in appropriate cases, in the humanities" (Bok, 2006, p. 134). Steen (2004) notes that QR programs should involve faculty from many disciplines, and that the social sciences may be especially well-positioned to lead QR initiatives.

QR is widely recognized as an essential competency (AAC&U, 2009). Poor quantitative skills have serious socioeconomic consequences in areas

such as healthcare (Cavanaugh et al., 2008; Master et al., 2010; Nelson et al., 2008) and the legal system (Schneps & Colmez, 2013). Conversely, quantitative proficiency promotes academic success, bring advantages on the job market, and allows individuals to participate more fully in civic life (Baer et al., 2006; Barton, 2000; Bennett, 2013; Geiger et al., 2015; Geiger et al., 2018; Kirsch et al., 2007; Paulos, 2001; Schuhmann et al., 2005; Steen, 2002). According to Gal et al. (2020, p. 391), QR "should be one of the key targets for policy-driven educational interventions that aim to improve the social and economic status, and overall well-being of low-skilled or otherwise vulnerable adults." Karaali (2020) even suggests that QR is a "tool for survival" needed to make sense of social and political developments such as the COVID-19 crisis and the #Blacklivesmatter protests.

Establishment of the QR Faculty Development Program

The program described here was developed and administered as a series of three initiatives. The first of these, the Lehman College QR faculty development program, was founded in 2010 and enrolled about a dozen faculty and doctoral students each year for five years. Participants met monthly for ten 3.5-hour sessions to learn and discuss strategies for effective QR teaching, develop instructional/assessment materials, and receive feedback from the leadership team as well as the other program participants. The second initiative, the Numeracy Infusion Course for Higher Education (NICHE), trained and supported faculty from nearly all the CUNY colleges in their QR teaching and assessment. Delivered chiefly online but with some face-to-face components, NICHE built upon the foundation established by the Lehman College program, enrolling summer cohorts of faculty in 2013, 2014, and 2015. Finally, with additional NSF funding, the program was adapted in 2017 to provide greater support for the CUNY community colleges. The Numeracy Infusion for College Educators (NICE) program focused on the needs of Hispanic-Serving Institutions (HSIs) in the Bronx, enrolling two cohorts in 2017 and 2017–2018. All three programs enrolled faculty in a wide range of fields and successful completers received stipends of $1,500–$2,000.

Structure of the QR Faculty Development Program

Darling-Hammond et al. (2008, p. 5) have argued that learning is best accomplished through activities such as "(1) creating ambitious and meaningful tasks, (2) engaging students in active learning, (3) drawing connections to students, (4) scaffolding the learning process, (5) assessing student learning continuously, [and] (6) providing clear standards and constant feedback." Indeed, successful

QR instruction requires *progressive pedagogy*: "connecting content to real-life situations, lighter coverage of topics, an emphasis on understanding concepts rather than facts, [and] integrating content across disciplinary boundaries" (Cuban, 2001, p. 89). Progressive pedagogy underlies every unit of the CUNY QR program. Participating faculty review key literature, then engage in activities and prepare instructional materials that are anchored in these approaches. A comprehensive review of appropriate strategies can be found on the QR website (http://www.teachqr.org), and several of the NICHE program exercises have been described by Wilder et al. (2013).

Unfortunately, many colleges fail to acknowledge the challenges involved in embedding QR across the curriculum—challenges that include a limited understanding of numeracy, a lack of commitment, and inadequate basic skills (Carter et al., 2015). Our QR program directly addresses many of these difficulties. Specifically, NICHE and NICE have been designed to provide instruction on best practices for teaching QR, to foster the development of instructional materials that make use of effective strategies for teaching QR, to infuse QR into a wide range of disciplines, to increase faculty interest and comfort in teaching QR, to strengthen the faculty's own QR skills, and to establish a network of faculty who are committed to improving students' QR capabilities. The participants in our program are selected through a competitive admissions process that requires them to describe what QR means to them and what they hope to get out of the program. Moreover, our approach to faculty development relies on the same active learning and discovery-based methods that have proven effective in the teaching of college students. Program participants engage in active learning activities such as graphing stories, describing their mathematical autobiographies, and solving quantitative puzzles.

The NICHE and NICE programs each incorporated a two-day face-to-face introductory session as well as eight one-week online units. The eight units, delivered through Blackboard and supported by the materials on the NICHE website (http://www.teachqr.org), covered QR and making numbers meaningful; QR learning outcomes; the brain, cognition, and QR; QR and writing; discovery methods; representations of data; QR assessment; and QR stereotypes and culture. Each unit included readings, videos, hands-on activities, interactive discussions, and the development and critique of activities or assignments prepared by participants for use in their own courses. Participants were required to develop their QR learning goals, provide and receive feedback, and revise their goals in response to that feedback; and to follow parallel procedures for the development of lesson plans/exercises and assessment plans/instruments. For each task, we provided detailed instructions and guidelines for peer review. All of the faculty received extensive feedback on their work, both from the leadership team and from their peers in the program. The instruction was

asynchronous, but with a deadline for the completion of each unit. We considered faculty to be *completers* if they submitted all, or nearly all, the required materials for any of the three programs. The vast majority of participants demonstrated a strong commitment to this work.

Data and Methods

The assessment data presented here represent 112 program participants—42 from the Lehman College program (including 7 doctoral QR Fellows), 44 from the NICHE program, and 26 from the NICE program.[2] The study received IRB approval, and consent forms were obtained from all participants. For the Lehman College program, anonymous assessments were administered during the final in-person meeting with each cohort. For NICHE and NICE, faculty participants completed online questionnaires at the beginning and end of the program. Among other things, the surveys collected information on participants' motivations for enrolling in the program and their perceptions of how the program had influenced their approach to teaching QR. In presenting the results, we have focused on the frequency of each response and on the thematic evaluation of the open-ended comments.

We cannot discount the possibility that social desirability bias influenced the responses we obtained (Grimm, 2010), especially since some participants were recruited by their department chairs or by faculty leaders of the programs. We did attempt to minimize the effect of any bias, however. For example, NICHE/NICE participants were assured that their identities would never be linked to any of their responses. Moreover, respondents were told that they could skip any question and there was no expectation that every open-ended question would be answered.

Program Participants

Overall, 123 participants were admitted to the program and 102 completed it (Table 1). Of the 15% who did not finish, most withdrew due to inadequate time, other commitments, or personal reasons. For each program, the overwhelmingly majority of completers were women and/or members of underrepresented groups (60%, 78%, and 78%). Although the Lehman program was restricted to a single four-year college, 42% of NICHE completers and 78% of NICE completers were community college faculty. The social and behavioral sciences (43%), the humanities (24%), the life and physical sciences (11%), mathematics and computer science (12%), health and social work (6%), education (4%), and the libraries (1%) are all represented among program completers.

Table 1 | Key Features of the QR Faculty Development Programs

QR Program and Funding Source	*Mode of Delivery and Years of Program*	*Target Population*	*Recruitment*	*Attrition from QR Program*		*Assessment Participation*		
				Number Admitted	*Completers*	*Total Pre-Workshop*	*Total Post-Workshop*	*Participants in Assessments*
Lehman QR Program (Lehman College)	Ten in-person monthly sessions during the academic year, 2010–2015	Lehman faculty	Flyers sent to all faculty and chairs via Lehman email; also word of mouth and personalized recruitment by QR program directors	53 (43 faculty and 10 QRFs)[a]	43 (35 faculty and 8 QRFs)	No pre-workshop assessment	42 (35 faculty and 7 QRFs)	42 (35 faculty and 7 QRFs)
NICHE (NSF)	Two-day in-person kickoff meeting followed by 8 online weekly units during the summer, 2013–2015	CUNY faculty	Flyers sent to administrators, directors of teaching and learning centers, some college listservs, and some department chairs; also word of mouth and recruitment by program directors	44 faculty	36	44	36	44
NICE (NSF)	Two-day in person kickoff meeting followed by 8 online weekly units during the summer or 8 monthly units during the academic year, 2017–2019	Faculty at 3 CUNY HSIs in the Bronx		26 faculty	23	26	17	26
Total				123	102	70	95	112

[a]The QR Fellows (QRFs) were assigned to various CUNY colleges by the CUNY Graduate Center. Since the strongest QRFs were also wanted by other colleges, we typically received a mix of our most desired candidates along with others we ranked as acceptable.

Of the 105 faculty who participated in the assessments, 15% were adjunct faculty, 17% instructors/lecturers, 42% assistant professors, 17% associate professors, and 9% full professors. Of the 102 who provided data on how long they had been teaching, 12% had been teaching for less than 5 years, 35% for 5–9 years, 24% for 10–15 years, and 29% for 16 or more years. We recruited faculty who were active teachers and who had agreed to pilot their QR instructional materials in the semester following program completion. Faculty participated as individuals, although some were course coordinators who planned to distribute their materials to their colleagues.

Motives for Participating

Survey Results

Table 2 shows respondents' stated reasons for participating in the program. Among the options provided, "concern for students" and "interest in course topic" were identified as *very important* by more than 78% of respondents and as *very important* or *somewhat important* by more than 96%. (We did not ask faculty to rank the items, so we cannot ascertain the weight they assigned to each.) More than 70% of respondents indicated that faculty networking was *very important* or *somewhat important*, and nearly half gave these same responses with regard to financial compensation. Incentives such as cash or reassigned time have been identified as key factors in encouraging course redesign (Abes et al., 2002), and our findings suggest that faculty do respond to monetary incentives even in the presence of more important considerations that lead them to participate.

Most faculty, both in-person and asynchronous, reported that convenient timing/scheduling had influenced their participation. The Lehman program participants met monthly, Friday mornings, for 3.5 hours. The NICE and NICHE programs kicked off with a two-day in-person workshop but were otherwise delivered virtually and asynchronously.

Finally, nearly a third of the NICHE/NICE faculty reported that tenure or promotion considerations had influenced their decision to participate. This response was especially common among community college faculty—those most likely to feel that teaching is valued at their institutions (Leslie, 2002).

Qualitative Results

The survey distributed at the beginning of each NICHE/NICE cohort asked faculty to indicate "what factors motivated you to enroll in [the program] and what you hope to get out of [it]." Sixty faculty responded to this open-ended

Table 2 | "Please rate the importance of the following factors as reasons for your participation in the QR faculty development program"[a]

	Concern for Students	*Interest in Course Topic*	*Faculty Networking*	*Convenient Time*[b]	*Convenience of an Online Course*[c]	*Financial Compensation*	*Helpful for Tenure/ Promotion*[d]
% Very important	81.0	78.1	32.4	22.9	18.6	14.3	12.7
% Somewhat important	19.0	18.1	38.1	28.9	32.9	34.3	18.3
% Neutral	0.0	1.9	17.1	22.9	30.0	10.5	31.0
% Somewhat unimportant	0.0	0.0	4.8	8.6	10.0	20.0	9.9
% Very unimportant	0.0	0.0	4.8	17.1	5.7	13.3	15.5
% Not applicable	0.0	1.0	2.9	0.0	2.9	7.6	11.3
% Missing	0.0	1.0	0.0	0.0	0.0	0.0	1.4
n	105	105	105	35	70	105	71

[a]For NICHE and NICE, these questions were asked in the pre-workshop assessment. These questions were not asked of the QRFs.

[b]Asked only of Lehman in-person participants.

[c]Asked only of NICHE/NICE enrollees.

[d]Not asked of the first two cohorts of the Lehman QR Program or of the first NICHE cohort.

question. In their comments, faculty universally indicated that they hoped to learn methods and tools for teaching QR. These sentiments were expressed not just by faculty new to QR instruction, but by those who regularly taught quantitative courses. For example, one NICHE participant who taught mathematics at a community college noted, "I'm always looking for new ideas about how to reach different students and effectively teach mathematical concepts rather than procedures or memorized facts."

Several faculty pointed out that colleges have an obligation to help students develop their QR and critical thinking skills. A faculty member in English (NICE) wrote, "I see students struggle with reasoning in general, including quantitative reasoning, and I want to help them with a skill that is applicable in the real world." A faculty member in urban studies at a four-year college (NICHE) wrote, "I [would] like to figure out how to integrate quantitative reasoning for students who are maybe uncomfortable reading graphs, percentages, etc." Likewise, a sociology professor at a community college (NICE) reported, "Many students enter my class not understanding research. . . . I don't always get to teach about the data or how to think with data. I want to teach students QR so they can comprehend and communicate data for research/academic and/or professionally as many enter into the criminal justice field directly after earning their [associate's] degree."

Thirty-five percent of respondents specifically mentioned their students when discussing their reasons for joining the program. A faculty member in literature and cultural studies at a four-year college (NICHE) remarked, "I want my students to be much better equipped to interpret and reason with mathematical concepts. The state of mathematical literacy is [appalling] in contemporary American culture, and it seems to me that the two most essential jobs we have as educators in public higher education is to teach students to read and write clearly and logically, but also to interpret and reason with statistical data." A sociologist at a four-year college (NICE) expressed a similar view, stating, "I [have] have made two commitments that undergird my work: writing and quantitative reasoning."

The faculty's comments about their students often focused on math phobia and weak quantitative skills; 23% of respondents mentioned these major areas of deficiency for CUNY students (CUNY, 2015; Wilder, 2009). As a professor of management at a four-year college (NICHE) noted, "A significant number of my students . . . actually give up before trying [when] confronted with quantitative problems." Many faculty expressed the hope that NICHE/NICE would provide them with the tools they need to make students more comfortable with quantitative concepts and methods. For example, a NICE participant at a four-year college wrote, "In [statistics] class, as well as in others, I often encounter a lack of basic mathematical understanding. It is not so much the

calculation errors that worry me, but the lack of numerical logic displayed by many students. I also hear the 'I'm bad at math' excuse at least twenty times per semester and I want to gain some tools to help students overcome this prejudice toward math."

In their comments, 14% of participants stated that they had joined the program at least partly to network with other faculty. As a faculty member in mathematics at a community college wrote, "I am also new to CUNY and thought it would be a good way to network and meet other faculty members who would have similar interests."

Eleven percent of respondents mentioned a desire to learn methods they could pass on to their colleagues or graduate students. A psychology faculty member at a four-year college (NICHE) stated, "I would like to improve the teaching of statistical reasoning in my department and in my classes. I would also like to better mentor and improve instruction in the classes taught by grad students and adjuncts that I oversee. I also hope to learn more about assessment and evaluation of conceptual learning." As this last comment suggests, a few participants mentioned the need to improve not just their teaching but their ability to *assess* QR. For example, a community college faculty member in psychology wrote, "I was particularly interested in NICHE because I am a member of the assessment team in my college. I have helped revise our QR rubric and participate in benchmark readings for gen ed competencies. I think NICHE is directly relevant to my work with assessment."

Finally, three respondents reported that they wanted to improve their own QR skills. A NICHE participant in education wrote, "I regret not having repeated and reinforced my math skills over the years and not having taken formal work in statistics. I hope to have a better understanding of my own assumptions and misconceptions in QR as well as to identify activities and concepts I can embed in my work with students and faculty." A professor of English at a four-year college (NICHE) had a similar goal: "My own inadequacies with QR pale in comparison with my students' quantitative literacy. I hope to strengthen my [quantitative] skills." Likewise, a community college faculty member in history (NICHE) stated, "I hope to get out of this course more comfort with QR for myself and confidence that I could support students if I integrate QR into my curriculum."

What Faculty Get Out of the QR Program

Survey Results

Table 3 shows the perceived impact of the QR program on faculty who completed NICHE or NICE. More than 90% of respondents *strongly agreed* or

Table 3 | "As a result of my participation in NICHE/NICE, I . . ."[a]

	Plan to place a heavier emphasis on QR in my course instruction	*Have become familiar with new strategies and tools for teaching QR*	*Have become engaged in CUNY network faculty committed to QR instruction*
Strongly agree	60.4%	67.9%	52.8%
Somewhat agree	30.2	22.6	32.1
Neither agree nor disagree	5.7	9.4	13.2
Somewhat disagree	3.8	0.0	1.9
Strongly disagree	0.0	0.0	0.0

[a]These data include all 59 NICHE/NICE completers except for six who completed most, but not all, of the required activities.

somewhat agreed that they would be placing a heavier emphasis on QR in their courses. Likewise, more than 90% indicated that they had become familiar with new strategies and tools for teaching QR, and 85% reported that that they had become engaged in a network of CUNY faculty committed to QR instruction. Clearly, faculty participants feel they have accomplished three of the goals that led many of them to participate in the program.

Qualitative Results

An open-ended survey question asked faculty to reflect on whether and how their approach to teaching QR "had changed (or will change)" as a result of the program. Ninety-two of the 102 program completers answered the question. (Nine did not answer any of the post-assessment questions, and three skipped this particular question.) Of those who provided feedback, 94% indicated that their approach to teaching QR had changed. The most widely reported responses are described below, under six general categories: (1) understanding of QR and commitment to QR instruction; (2) systematic methods of infusing QR into teaching; (3) new pedagogies and resources; (4) awareness and sensitivity to students' needs; (5) QR assessment strategies; and (6) obstacles to change.

Understanding of QR and Commitment to QR Instruction

Nearly a third of the faculty reported that they had gained a better understanding of what QR entails, its relevance to their teaching, and the importance of

incorporating QR into their courses. A faculty member in sociology at a four-year college distilled the sentiments of many respondents:

> I did not even think about infusing QR into my sociology courses until I took this workshop. I was not introduced to the concept of QR anywhere in my own doctoral study and had very little QR learning after my first year of college, so you can imagine how eye-opening this experience was for me. I realized how important it is to include QR in the construction of activities and assignments for all of my courses and had to take a step back and look at my syllabi in a whole new way.

Several faculty stated that the workshop helped them to better understand the nature of QR and the ways in which it is distinct from mathematics. An economics professor at a four-year college (NICHE) wrote,

> I have fundamentally changed my attitude toward both math and QR. I can now determine what is QR and what is math even though overlap does exist. I also will no longer openly accept [the assertions of] students who say they do not like math, do not want to take a class with math, etc. My attitudes have really changed. Math may continue to be calculus and algebra, but QR and [its] connection to daily living is what I have come to learn and really appreciate. I feel more comfortable, and I hope that translates to the students.

Likewise, a faculty member in office technology at a community college (NICE) commented,

> This workshop has helped me to look at numbers differently and separate numbers from pure mathematics. The idea is to get the students to view QR as an everyday reality and look at the way they arrive at problem solving. I plan to teach the course incorporating QR to change their mind about numbers and problem solving, the way this workshop and working with the QR fellows at my institution has helped change my attitudes.

Several respondents stressed that QR is more than just mathematics. For instance, a psychology professor at a community college wrote that NICE had given her "a clearer picture of how QR fits into Gen Ed and [its] importance to all students." Even faculty in highly quantitative fields reported a better understanding of QR and its importance. As a Lehman College mathematics professor stated, "I have altered my . . . understanding of what QR is."

Many respondents planned to intensify their efforts to integrate QR into their courses. A business professor at a community college (NICHE) summed

up these sentiments when she wrote, "I will place a much heavier emphasis on building quantitative reasoning skills. . . . QR has the potential to stay with them long after the final." Likewise, a NICE participant teaching English at a community college stated, "There was no QR component to my composition course previously. There now will be. So there is infinitely more QR than there used to be." A psychology professor reported much the same thing: "[the Lehman College QR workshop] has encouraged me to continue and even to expand my QR activities a bit. I certainly feel a lot better about stressing QR in my courses."

Some participants noted that the interdisciplinary nature of the program had helped them see the applicability of QR to all fields, including their own. A faculty member in social work wrote, "The mixed faculty workshop was an excellent format for me to engage the interface of liberal arts and STEM. I will actively create assignments and engage my students in QR exercises and reasoning as part of development of analytical skills in social policy topics."

Several participants in the Lehman College workshop described how it had led them to consider how they might incorporate QR into their teaching. For example, a professor of music wrote, "I have more ideas about critical reasoning which can be reinforced throughout the curriculum. . . . Plan to look for ways of including some element of QR in each course, including graduate research classes." Likewise, a faculty member in political science discovered "new ways of integrating quantitative thinking and QR assignments [with] 'non-quantitative' courses." These same sentiments were expressed by participants in the NICHE and NICE workshops. A community college faculty member in mathematics reported, "Things that I have been thinking about or have been taught in the past were solidified for me. Also, I got a good sense of what QR is and its importance. Further, I learned new things as well about QR, cognition, and the brain." Similarly, a NICHE participant teaching French at a community college wrote,

> The use of QR in the language classroom still seems to me to be more intuitive than the strict application of QR teaching methods, but NICHE has definitely made me more aware of the more concrete application of QR and, above all, of the desirability of getting more QR in the classroom. I will continue to experiment with QR in the classroom and monitor how it affects the results I am striving for.

This emphasis on experimenting with new approaches was readily apparent in many of the respondents' comments. In fact, several program alumni have published or presented descriptions and assessments of their QR teaching innovations (e.g., Fisher et al., 2019; Bertels et al., 2015).

Systematic Methods of Infusing QR into Teaching

One third of respondents indicated that they had learned systematic strategies for implementing QR into their teaching—e.g., the articulation of learning goals, the design of learning opportunities, and the assessment of student learning. An associate professor in psychology at a community college wrote,

> Through NICHE I acquired a systematic method for infusing QR in my courses, beginning with establishing and ending with assessing clear goals. I plan to develop more QR lesson plans following the active learning method we learned in NICHE. I want to gradually turn all my lessons into active learning ones wherein students can actively work with data.

Quite a few participants mentioned their newfound awareness of more deliberate and methodical methods for teaching QR. For example, a faculty member in biology at a community college (NICHE) wrote, "I will be more intentional in my incorporation of QR into my teaching. It's too easy to just throw it in as part of what's being discussed, rather than having a course plan and lesson plans that deliberately address and assess QR." Likewise, A QR fellow in accounting reported, "I had included QR materials in my teaching but not in a systematic way. After the QR workshop, I am planning to . . . make QR objectives a part of the syllabus, and assess students' QR performance at the end of the semester."

Several faculty remarked that they had become more thoughtful about the incorporation of QR into their teaching, and a biology professor described how this approach had already been successful with students: "Students responded very well to my use of subjects in the media to construct course materials and QR." Likewise, a faculty member in education at a four-year college (NICE) wrote, "I am more thoughtful of connecting my intentions (goals) and assessment measures for sure!" and a professor of economics stated, "I am more conscious of how I am approaching the topics and what is expected of my students in class as well as in terms of their assignments."

Several respondents reported that the program had led them to emphasize QR more deliberately. A faculty member in American Studies at a four-year college wrote,

> The major change will be that I teach QR consciously as a result of NICHE; prior to taking the course, I did not really incorporate QR into my classes, but now I have incorporated consciousness of QR and numeracy into all the courses that I teach, and I believe that incorporating QR is essential for teaching composition in a way that incorporates critical thinking, which is one of the topics we should be teaching in ENG 110.

Likewise, a faculty member in urban studies at a four-year college wrote, "Through NICHE, I realize that I can design discrete assignments that integrate QR and writing and fit them into specific course modules. I am already thinking about how to integrate a census based assignment in my courses." Another social scientist stated, "The most important thing I learned is how to consciously and systematically incorporate QR in my teaching. . . . Now I know how to come up with specific QR learning goals and create learning activities that will help me achieve those goals."

Respondents also indicated that their newfound knowledge of QR teaching methods had made them more confident in teaching QR. A marketing professor in the Lehman College workshop commented, "I have always valued QR but had little confidence that I could transfer my values to my students. This workshop emboldened me to challenge my students by daring to teach the skills and [requiring] them to use them." Likewise, a faculty member in the humanities (NICHE) wrote,

> I am much more confident in my understanding of QR in terms of philosophy, pedagogy, and goals. It's hard to break old habits of teaching literature primarily as a conversation in which beautiful words float serenely above the mundane world of numbers and facts. . . . We all know that QR is essential to preparing our students for the twenty-first century, but the rise of digital humanities suggests that QR is also essential for preparing twenty-first-century students to study centuries past. I spent countless hours this summer blazing a Google trail inspired by our readings, videos, and assignments, and I discovered an abundance of resources applicable to my teaching of African American literature. . . . Thank you for challenging my comfort level and enriching my teaching.

Similarly, a faculty member in social work at the Lehman College workshop noted, "Although I always believed in the importance of QR, I now feel I am able to operationalize in teaching. I also will pair it with writing/critical thinking skills." Because some faculty are initially reluctant to teach QR, instruction in QR concepts and methods should be accompanied by deliberate efforts to bolster the confidence of program participants.

New Pedagogies and Resources

As described earlier, the QR workshop promoted the use of best practices such as active learning, constructivist learning, collaborative work, revisions of assignments, and pairing QR with critical reading and writing. In addition, we introduced faculty to a range of online tools for teaching QR such as Google spreadsheets and Gapminder (see www.teachqr.org.). In their comments, many

faculty stated that they planned to incorporate these best practices into their teaching, even apart from their QR-related instruction. A professor of psychology at a four-year college (NICHE) wrote, "[I'm] going to try to use more constructivist, activity-based learning approaches. I'm not able to totally flip my class but [I want to] spend much less time going over PPTs and more time going over examples and activities." Likewise, a faculty member in English at a four-year college (NICHE) stated, "I am going from QR practically zero to QR as a catalyst for discussion and writing. I always use data in my classes (I present statistics, or throw numbers into my lectures, [e.g.,] "Unemployment in Ireland in year ____ was ____%" as cultural context for readings.) Now I am going to ask students to look at data and come to their own conclusions!"

A NICHE participant teaching psychology at a four-year college described how she planned to change her approach to QR instruction:

> (1) I see QR as a more important and less formidable skill for students to develop than I previously did. (2) I will have students engage in more QR-related activities. . . . (3) I will use more constructivist approaches to teach QR. . . . (4) I will have students work with actual data to develop QR, something I did not do before. (5) I will be more confident in my ability to teach QR.

A QR fellow in computer science outlined a similar approach:

> Certainly I will incorporate a lot of strategies learned from this program, particularly: 1. constructivist teaching (learning): e.g. "ask—wait" instead of ask . . . give explanations. 2. Learning goal-setting becomes more important. 3. Web-based tools. 4. I used to have questionnaire for students, three to four times in a semester. Such routine will be [turned] into self-assessment figures.

Another QRF stated, "[I have thought about how to] use constructivist approaches to help scaffold learning, and have students write about statistical findings, and generally re-work my classes in ways that I think will both encourage interest and prepare students for working with numbers." A few respondents mentioned specific pedagogical resources they had identified through the QR program—Gapminder, in particular.

Awareness and Sensitivity to Students' Needs

Throughout the faculty development program, we discussed topics such as stereotype threat and the need for sensitivity to individuals' varying levels of preparedness and comfort. In their comments, about a dozen participants stressed

the need to introduce QR concepts gradually. A faculty member who taught reading, literature, and writing (NICHE) wrote,

> [I now move] more slowly when I introduce data for students to interpret. I believe I have tended to approach the interpretation of data like I approach the interpretation of texts. When working with a text, I am confident that students can start anywhere, with any observation they make, and work their way to a fuller interpretation of the whole text and its [significance]. With quantitative data, I think that students need to work in a more methodical way to develop accurate and useful interpretations.

Likewise, a psychology professor at a community college wrote, "I will certainly pay closer attention to my students' QR skill development and their understanding of the [quantitative] information we discuss in class. I plan to work QR questions into more assignments and make more time to help students master QR problem solving." A faculty member in sociology at a community college (NICE) remarked,

> I used to mention percentages and show charts or graphs to students often. I thought my introduction of the data was necessary and informative, which it is, but I never realized how students do not actually understand the numbers or know how to calculate percentages or read charts or graphs. I had to take a step back and gear my lectures/discussions to teach QR skills so students can truly comprehend the material and be comfortable with numbers/data.

Beginning with the 2013 cohort, the QR program included a unit on cognition that highlighted Kahneman's (2013) book *Thinking, Fast and Slow* (Wang & Wilder 2015). Kahneman describes the two systems that characterize the way we think. System 1 is faster, instinctive, and emotional while System 2 is slower, deliberate, and logical. Quantitative reasoning is "effortful" and demands System 2 thinking. As a result of this discussion, several faculty described the need to infuse System 2 thinking into their teaching of QR. An economics professor wrote, "First thing that I have learned is that each assignment has to be written very carefully. Second, the assignment has to be explained in class orally and [slowly]. Finally . . . topics that pertain to the QR need to be embedded and emphasized throughout the course and frequently." A faculty member in sociology at a community college (NICE) remarked that "repetition and additional explanations are always needed." Likewise, a faculty member in political science at a four-year college (NICHE) wrote, "In most of the courses I teach, QR is limited and implicit. That is, I assume that students can do some things and, in a cursory way, go over the more complex tasks I want students

to complete. I will now devote some time to explicitly teaching QR in all of my courses and give students activities and assignments to build those skills."

A few faculty remarked that they could accomplish more by focusing on a narrower range of QR skills than by trying to cover everything. As a professor of psychology at a community college (NICE) concluded, "It's better to teach one thing well than to teach everything not so well!" Likewise, a faculty member in allied health at a community college wrote, "I will look at every assignment from the perspective of where the students are coming from and where they need to be after each lesson."

Two faculty in English emphasized the importance of a well-organized, coordinated approach to teaching QR. One wrote, "Since I teach 1st semester freshmen, I became aware how much I must breakdown/scaffold in introducing the QR assignment." Another remarked,

> I have frequently used data for writing assignments but I realized during this workshop that I was not providing any support for students (I didn't realize that they needed support for both the math and the reasoning). I also know that in order to get students to think quantitatively in a humanities course I have to make sure that the QR is relevant. . . . I will be teaching an LEH 300 course in the fall and I plan to have a short weekly QR assignment that will introduce students to demographics and data. I know, now, that short relevant QR exercises work in [the] humanities!

QR Assessment Strategies

About a dozen respondents singled out assessment when discussing how their approach to teaching QR had changed. Nearly all the faculty who focused on assessment were from traditional STEM disciplines. Several mathematics faculty described how they had come to embrace assessment. For example, a math professor at a community college (NICHE) wrote, "I have always used QR type activities in my teaching. What has changed is the assessment aspect of the teaching. I now plan to focus on assessment of the QR activities. The benefit of this to me is that as I think of assessing, it also refines my teaching goals and creating lesson activities to target those goals." A professor of chemistry at a four-year college distilled the sentiments of many when she wrote,

> NICHE education gave me a push that I should rewrite learning goals for each unit, creating a blueprint of how to create a lesson plan with possible online videos and other supporting materials to meet the learning goals. I am also satisfied now that assessment is important, which would never be my statement without NICHE. I will be creating pretest, rubrics and assess

each unit to see whether the learning goals are achieved. This also helps me to evaluate my teaching methodology and focus more on areas where students need help.

Likewise, a biology professor at a four-year college remarked, "I will do more pre- and post-testing since I now have explicit QR goals. I will also work with other faculty in my department to help develop a QR oriented mind set in all teaching."

A few faculty outside the sciences mentioned assessment as well. For instance, a history professor at a community college (NICHE) noted, "I would certainly include pre- and post-tests to gauge skills and infuse QR assignments through my course, which I had never done before." Similarly, a faculty member in management at a four-year college wrote, "I like the idea of assessment, which I think is very important especially for our students. So I think I will implement more pre and post tests." Another, in geography, stated that the program had helped him "strengthen the link between learning goals and assessment."

Obstacles to Change

Just three respondents indicated that they did not expect to make any changes as a result of the QR faculty development program. A mathematics professor at a community college stated that her approach to teaching wasn't likely to change because she had already been using most of the strategies covered in the program. She did mention, however, that "it was nice to become more acquainted with people across CUNY who are interested in integrating QR into their courses." Another NICHE participant, in political science, had no plans to change her teaching because she felt that many QR strategies were "too time consuming." This comment may reflect the individual's technological difficulties with Blackboard and the problems she encountered while navigating the online course. Although most participants felt that they had benefitted from the program, faculty-based QR initiatives are not for everyone. Best practices often require significant time and effort.

Discussion and Conclusions

Given the importance of numeracy in all aspects of life, the need for well-designed, multidisciplinary QR faculty development programs is critical. As McLean et al. (2008, p. 569) have argued, "Any faculty development programme should endeavor to initiate and sustain change." As shown here, the CUNY QR program sparked a movement among faculty to improve their students' QR capabilities. The program drew a diverse population of faculty from a broad range of fields. Participants' survey responses and written feedback reveal that

most joined the program due to their concern for students' academic success as well as their interest in teaching QR. Participating faculty also valued opportunities for networking with like-minded individuals as well as the financial incentives associated with completion of the program. For most faculty, the convenience and timing of the workshop, whether in-person or online, were also important considerations. Those working at community colleges were especially likely to feel that the QR program would be helpful for their professional advancement. These motivating factors provide insights into the kinds of incentives that may be most effective in recruiting committed faculty for professional development programs.

Notably, there is a strong correspondence between what faculty hoped to get out of the program and what they feel they have gained. Upon completing the workshops, the overwhelming majority of participants stated that they would place a heavier emphasis on QR in their courses. They reported increased familiarity with key strategies and tools for teaching QR, and they felt a sense of engagement with the broader network of CUNY faculty committed to QR instruction. Many planned to more deliberately emphasize QR in their courses, to incorporate data analysis and real-world examples in their teaching, and to employ best practices such as the articulation of learning goals, the provision of opportunities for active learning, and the use of assessments that can help improve instruction.

Our faculty development program was grounded in a cyclical model of learning that includes the articulation of goals and outcomes, the development and implementation of instructional and assessment materials that address the outcomes, and the use of assessment data to inform and improve instruction. Program participants were mentored by program leaders and supported by an interdisciplinary, collaborative community of peers. Although we provided rubrics for the development of each instructional component (goals, instructional materials, and assessment instruments), faculty were given considerable flexibility in defining the content of the materials they developed. While this led to great variation in the nature and quality of those materials, it ensured that faculty had a sense of ownership over their work—a key factor in the success of the initiative.

Along with the cyclical model and the emphasis on pedagogical deliverables, our experiences suggest several other important components of effective QR training. These include (1) the selection of a group of highly motivated and committed faculty; (2) the use of a collaborative model that supports networking and builds a sense of community; (3) the incorporation of readings and videos on important topics that provoke reflection and discussion; (4) the modeling of best practices, including constructivist approaches and active learning; (5) a focus on students (e.g., reviewing samples of their QR work); (6) sensitivity to variations in faculty members' QR preparedness; (7) adequate incentives

for participation; (8) effective mentorship by program leaders; and (9) strong institutional support.

Many of our recommendations are transferable to other general education programs. For example, the cyclical model of instruction was regarded as very important by faculty participants, and it can be readily applied to initiatives in areas such as service learning and writing across the curriculum. Although the NICHE and NICE programs were supported by the NSF, institutions concerned with improving students' general education skills must commit the resources needed to effect positive change. If funding is limited, this might be accomplished through more broadly based workshops that focus on progressive pedagogies and address multiple general education fluencies, including QR. More important than funding, however, is an institutional climate in which faculty are valued and rewarded for taking risks and implementing new modes of instruction.

Our findings reinforce the work of earlier researchers who identified the important features of effective faculty development programs (Moseley, 1992; Proctor et al., 2020). They also highlight several elements that may be unique to QR instruction. Because QR sometimes takes faculty outside their comfort zones, our program demonstrated the need to structure the program in a way that is nonthreatening to participants. Moreover, the development of hands-on teaching and assessment tools seems especially important for QR instruction. Finally, the advantages of building a multidisciplinary community of practice are especially clear within the context of online QR training. Participants who interact in meaningful ways over time are more likely to recognize that QR has the potential to transform teaching across the disciplines.

Although nearly all the participants benefited from the CUNY QR program, the more enthusiastic faculty—those who made a serious commitment of time and effort—tended to gain the most. This was true even of participants with weak QR backgrounds, and the overwhelming majority of our faculty maintained or even increased their enthusiasm over the course of the program. Several participants have since pursued research on QR and on the scholarship of teaching and learning, and the instructional and assessment materials developed by many of the faculty can be readily adapted for use by other institutions.[3] To the extent that well-designed QR programs attract motivated and diverse faculty, programs such as this one can help institutions of higher learning respond to the challenge of innumeracy.

ESTHER ISABELLE WILDER, Professor of Sociology at Lehman College, CUNY, is co-founder of the Quantitative Reasoning (QR) faculty development program at Lehman College. She also serves as principal investigator and director of an NSF-funded faculty development program to increase students' QR skills through the implementation of a data analysis research experience (DARE).

Her earlier projects, also supported by NSF, have provided training to hundreds of faculty representing a wide range of disciplines across the social sciences, life and physical sciences, and humanities. Dr. Wilder's current research focuses on multidisciplinary QR initiatives and on the sociology of disability, inequality, and health behaviors and outcomes. She is the author of *Wheeling and Dealing: Living with Spinal Cord Injury* (Vanderbilt University Press, 2006) and coauthor of *Voices from the Heartland: The Needs and Rights of Individuals with Disabilities* (Brookline Books, 2005). Her scholarly work has appeared in more than a dozen journals including *Numeracy*, *Scientometrics*, *Studies in Contemporary Jewry*, *The Milbank Quarterly*, *Social Science Research*, *Sociological Perspectives*, *Teaching Sociology*, *The Gerontologist*, and the *Journal for the Scientific Study of Religion*.

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1. CUNY, the nation's largest urban public university, is "a transformative engine of social mobility" with 25 colleges that award 55,000 degrees each year (CUNY, 2020).

2. The QR Fellows (QRFs) were CUNY doctoral students required to enroll in the program and to serve as a resource for faculty participants as a condition of their funding. Although the QRFs participated in the assessment activities, they did not answer the questions about why they had enrolled.

3. See http://www.teachqr.org.

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