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Contextualizing Developmental Math Content into Introduction To Sociology In Community Colleges

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Abstract

Across community colleges in the United States, most students place into a developmental math course that they never pass. This can leave them without the math skills necessary to make informed decisions in major areas of social life and the college credential required for participation in growing sectors of our economy. One strategy for improving community college students' pass rate in developmental math courses is the contextualization of developmental math content into the fabric of other courses. This article reviews an effort to contextualize developmental math content (i.e., elementary algebra) into Introduction to Sociology at Kingsborough Community College and Queensborough Community College, both of the City University of New York, during the spring 2016 semester. Data from a pre-test/post-test control-group design implemented across the two campuses reveals the significance of this strategy for some sociology students' grasp of discrete mathematical skills and success in developmental math.

Keywords

data analysis, introduction to sociology, quantitative literacy, quantitative methods

Many authors talk about the need for mathematical literacy in a world where we are increasingly flooded with data. Graphs, charts, and tables on almost every subject are available at the click of a mouse, and each item proclaims its importance and the need for focused and undivided attention. Math as a tool for making things work has also become an ever-growing feature of the world in which we live. In many non-obvious ways, from the algorithms that power Internet search engines and the formulas that regulate surveillance cameras to the equations that govern

the readouts from our medical equipment, math is a central element of what makes 'the world go round.' Mathematical literacy is critical on both the individual level, in the evaluation of consumer and financial choices, and on the socio-political level, in evaluating policy outcomes and discerning the veracity of various political claims.

Approximately half of American undergraduates are enrolled in community colleges (Bailey and Jaggars 2016), and sixty-eight percent of them are placed into developmental math, reading, and writing courses to prepare them for college-level work (Center for Community College Student Engagement 2016). These courses carry no credit, although students must pay the regular tuition, and they are often prerequisites for courses in students' major or degree programs. Across community college campuses in the United States, students are most likely to enroll in a developmental math course, which many never pass (Bailey, Jeong, and Cho 2010). For example, at the City University of New York (CUNY), 70-80 percent of community college students must take a developmental math course, and students' pass rate for that course is around 40 percent (CUNY Office of Institutional Research and Assessment 2015).

Also significant is the disparity in math proficiency evidenced across groups of community college students. For instance, at CUNY's Kingsborough Community College (KBCC), the percentage of incoming first-year students who successfully complete the developmental math course within four years is 32 percent for Asian students, 28 percent for White students, and only 15 percent for both Black and Hispanic students (KBCC Office of Institutional Research, Assessment and Planning 2015). National-level data show differences in developmental progression across groups, as well. Male students, Black students, and part-time students are less likely than other students to complete their developmental coursework (Bailey,

Jeong, and Cho 2010). Taken together, these facts indicate that community college students' mathematical literacy is a social justice concern.

One strategy for improving community college students' pass rate in developmental math courses is the contextualization of developmental math content into the fabric of other courses. This article reviews an effort to contextualize developmental math content (i.e., elementary algebra) into Introduction to Sociology at two CUNY community colleges (KBCC and Queensborough Community College [QCC]) during the spring 2016 semester. Data from a pre-test/post-test control-group design implemented across the two campuses reveals the significance of this strategy for some sociology students' grasp of discrete mathematical skills and success in developmental math.

LITERATURE REVIEW

Typically, community college students' developmental math needs are met with more of the same—de-contextualized, standalone math courses organized in a lecture-style format that involves the instructor working out problems on the board and students doing practice problems at home. Yet, given that math curricula tend to reflect a sequential development of increasingly complex procedures, a purely procedural strategy falls short when all students reach college-level work. When faced with superficially novel or more difficult problems, students often incorrectly apply their poorly remembered procedures and make repeated computational errors (Stigler, Givven, and Thompson 2010). This is particularly true of developmental math students, who, despite repeated exposure to the traditional model of instruction, frequently lack the skills and knowledge necessary to move into college-level math (Givven, Stigler, and Thompson 2011).

Perin's (2011) research speaks to the significance of contextualizing instruction to improve developmental math students' reasoning skills and knowledge of basic math content at the college level. In her review of the literature on contextualization, she identifies two versions with demonstrated effectiveness. The most common is redesigning developmental math courses so that they teach math through the use of materials drawn from the occupational or subject area of interest to the student, such as construction math. The least understood approach, and the approach that is most relevant to this project, is the integration of developmental math content into the fabric of other courses.

Introduction to Sociology has long integrated math content for the improvement of students' quantitative reasoning skills (Sweet and Strand 2006). In fact, given that today's college students are living and learning in an incredibly data-rich environment, the American Sociological Association recommends that sociology instructors "infuse the empirical base of sociology throughout the curriculum" (McKinney, et al. 2004:ii). A considerable number of peer-reviewed publications in sociology document the positive effects of integrating data analysis modules on students' content learning, course engagement, and quantitative literacy (see, for example, Sweet and Baker 2011; Burdette and McLoughlin 2010; Howery and Rodriguez 2006). Yet, despite a potential overlap in curricula and learning goals/outcomes, Grauerholz and Gibson (2006) reveal that sociology courses rarely include significant math content: only 20 percent of sociology courses integrate data analysis modules, and the vast majority of these modules are found in upper-level research methods courses not offered in community college contexts. Moreover, many of these modules assume statistical knowledge and skills that few community college students develop because of the hurdle of developmental math. In addition, these modules are typically designed by sociologists with the sole goal of

increasing students' skills within the discipline. In contrast, the modules used in this project were designed by sociology and math instructors to create algebra-infused learning experiences that would increase students' knowledge and skills within sociology *and* developmental math.

PURPOSE AND RESEARCH QUESTIONS

In this project, we contextualized developmental math content into Introduction to Sociology. To ascertain the impacts of this contextualization, we asked two questions: 1) Does contextualizing developmental math content into Introduction to Sociology impact student learning on the aligned skills? 2) Does contextualizing developmental math content into Introduction to Sociology impact student outcomes in their developmental math course (Elementary Algebra), as measured by their performance on the CUNY Elementary Algebra Final Exam (CEAFE)?

METHOD

Instructional Setting

This study was conducted at KBCC and QCC, two of the seven community colleges in the CUNY system. In the fall of 2015, a total of 17,033 ethnically and racially-diverse students were enrolled in a variety of degree and non-degree programs at KBCC: approximately 35 percent of students were White, 32 percent of students were Black, 19 percent were Hispanic, and 14 percent were Asian or Pacific-Islander (KBCC Office of Institutional Research, Assessment and Planning 2016). During the same semester at QCC, a total of 15,493 ethnically and racially-diverse students were enrolled in a variety of degree and non-degree programs: approximately 30 percent were Hispanic, 28 percent were Asian or Pacific-Islander, 25 percent were Black, and 16 percent were White (QCC Office of Institutional Research and Assessment 2016).

As is typical at community colleges across CUNY and the United States, the majority of incoming students at KBCC and QCC are placed in developmental math, reading, and writing courses (Jaggars and Hodara 2011). In fall 2015, 66 percent of incoming students at QCC and 75 percent of incoming students at KBCC were placed into developmental math (QCC Office of Institutional Research and Assessment 2016; KBCC Office of Institutional Research, Assessment and Planning 2016). At the time of this study, and for the majority of CUNY students, exiting developmental math required passing Elementary Algebra with a score of at least 60 on the CEAFE and an overall course average of 74 percent (with the CEAFE score worth 35 percent of the overall course grade).

The CEAFE was implemented by CUNY in 2012 to replace a more generic exam prepared by an outside vendor. It consists of 25 multiple-choice questions, each worth 4 points, for a maximum possible score of 100. These questions cover standard Elementary Algebra content at a level and in a format defined by the CUNY Elementary Algebra learning objectives. Unfortunately, many CUNY students never pass the CEAFE. In fall 2015, 57 percent of KBCC students scored a 60+ on the CEAFE (740/1301), while only 41 percent of QCC students did the same (1060/2069). These pass rates are consistent with the student pass rate across CUNY community colleges at that time: only 40 percent of CUNY community college students scored 60+ on the CEAFE in fall 2015 (CUNY Office of Institutional Research and Assessment 2016).

In addition to their low pass rates, many KBCC and QCC students struggle to engage and apply the math skills necessary to succeed in introductory courses across the disciplines. While their remedial needs are one explanation for these struggles, another explanation is that students (and instructors alike) tend to see math coursework and skills as separate from or unrelated to

other academic and disciplinary contexts. To this point, at both KBCC and QCC, the Introduction to Sociology course does not have a mathematics prerequisite.

Participants

Study participants included students enrolled in nine sections of the Introduction to Sociology course at KBCC and QCC in the spring 2016 semester. Four of these sections (two on each campus) were taught by the first two authors using modules that integrated elementary algebra content into the course. Five of these sections (two at QCC and three at KBCC) were taught by two additional full-time sociology instructors as controls. All nine course sections were taught during the day. Students enrolled in the experimental sections of Introduction to Sociology without a priori knowledge of the study, and students came to the study from a range of mathematical backgrounds (i.e., needing developmental math, concurrently registered in Calculus I, etc.).

Following IRB protocol, data were only collected and analyzed from students who signed a consent form in the beginning of the spring 2016 semester. No data were collected from those students who declined to participate in the study or who withdrew from the course prior to the end of the semester. Additionally, students were allowed to opt out of the study at any point in the semester. In total, data were collected from 88 students enrolled in the four experimental sections and from 97 students enrolled in the five control sections.

Module Design: Experimental Sections of Introduction to Sociology

In the development phase of this project, the authors collaborated to create three modules that integrated elementary algebra content into Introduction to Sociology. These modules aligned

with topics that are often discussed in the Introduction to Sociology course: social deviance, social inequality, and social change. Three primary considerations guided the modules' design. First, while oriented towards the growth of students' developmental math skills, each of the three modules was designed to satisfy the learning outcomes of Introduction to Sociology. Thus, the modules led students through a mathematical analysis of specific concepts, theories, and examples from the sociology curriculum to reach a relevant sociological conclusion.

Second, because of CUNY's organization of developmental math, each of the three modules was designed to engage students in the use of math skills closely aligned with CUNY Elementary Algebra learning outcomes and the CEAFE exam. As a result, those study participants who had completed or were exempt from Elementary Algebra were familiar with the modules' math content and, more importantly, those study participants concurrently enrolled in Elementary Algebra stood to benefit from the modules' contextualization of that content.

Third, each of the three modules was designed to unfold in the same manner. Prior to the module's start, students were given a pre-class homework assignment that reviewed the math content for the module. This homework included a complete worked example and scaffolded problems taken from the *MyMathGPS*: *Elementary Algebra Guided Problem Solving* textbook.[1] In subsequent class meetings, students were introduced to the sociology concepts, theories, and examples that grounded the module. After this, they worked on an in-class assignment that connected the previously reviewed math content to this new sociological material. This work was conducted in groups as the instructor circulated to offer help and advice. Finally, students were given a post-class homework assignment meant to reinforce the math content. These assignments mirrored the style of the CEAFE exam.

The following modules emerged within the bounds of these design considerations. Given that they make use of and depend on students' sequential development of math skills, they are listed in the order in which they were and should be implemented.[2]

- Module One: Social Deviance – In this module, students learn concepts and theories related to the study of social deviance as they calculate proportions and percentages from data on historical changes in marijuana use across the United States. Students also analyze the relationship between a state's marijuana laws and patterns of usage.
- Module Two: Social Inequality – In this module, students learn concepts and theories related to the study of social inequality as they analyze graphs of linear equations and construct linear models to compare student test scores across New York City public school districts. Students also examine the relationship between test scores and the demographic composition of a district.
- Module Three: Social Change – In this module, students learn concepts and theories in the study of social change as they use linear models and solve linear inequalities to estimate when the non-white population of the United States will exceed the white population of the United States.

Instruments/Measures

This study used three instruments to gauge participants' mathematics learning. The first two were a pre-test and a post-test, each consisting of five multiple-choice questions taken from practice CEAFE's—an exam whose outcomes are known to be normally distributed. The questions' topics/skill requirements aligned with the algebra used in the experimental sections: proportions; percentage increase; finding the linear equation of a straight line given two points;

solving a linear inequality; and converting an equation in verbal form into a mathematical equation.

The third instrument was the CEAFE, itself. The CEAFE scores of students *concurrently* enrolled in Elementary Algebra and an experimental or control section of Introduction to Sociology were examined, as were the highest CEAFE scores of those students who had taken Elementary Algebra *prior* to their enrollment in an experimental or control section of Introduction to Sociology. Significantly, given the availability of students' responses to individual CEAFE questions, it was also possible to examine students' scores on the five CEAFE questions that corresponded to the five questions on the pre-/post-tests.

Procedure

All students were administered the pre-test within the first three weeks of the spring 2016 semester. The post-test was administered to all students within the last three weeks of the same semester. After collecting the pre-/post-tests from the experimental and control sections on their respective campuses, the first two authors collated individual students' responses on each of the instrument's five questions into Excel. The resulting Excel files were shared with the third author in June 2016. In the summer of 2016, the third author requested the consenting students' CEAFE scores from CUNY's Office of Institutional Research and Assessment. These data were added to the aforementioned Excel files for analysis.

RESULTS

To answer the study's research questions, the third author employed paired T-Tests and Welch Two-Sample T-Tests to examine mean student performances on the pre-test, post-test, and the

CEAFE for the experimental and control groups.[3] The data were analyzed using the R software package.

First we examined if, at the time of enrollment, students in the experimental and control groups were similar in their math backgrounds and abilities. Data suggest that both groups of students had comparable math backgrounds and abilities at the time of their enrollment in Introduction to Sociology. For example, there was no statistically significant difference between the experimental and control students' average scores on the pre-test (Table 1). In addition, while roughly one third of the students in each group had previously taken an Elementary Algebra course including the CEAFE, there was no statistically significant difference between their average scores on that exam.

Table 1 about here

Next we consider if contextualizing developmental math content into Introduction to Sociology positively affected student learning on aligned skills. Table 1 presents the average post-test scores for students in the experimental and control groups. It is notable that experimental students' average post-test score (3.44/5) was higher than their average pre-test score (3.21/5), while control students' average post-test score (2.70/5) was lower than their average pre-test score (3.00/5). It is also notable that, while there was no statistically significant difference between experimental and control students' average pre-test scores, there was a very strong statistically significant difference between the experimental and control students' average post-test scores. While other factors may be at work, experimental students' increased average post-test score, as well as the statistically significant difference between experimental and control students' average post-test scores, suggest that the contextualization of developmental

math content in Introduction to Sociology had a positive impact on at least some students' mathematical understanding of the modules' topics. We include the measured language of "some students" given our analysis of participants' *average change* in scores from pre-test to post-test. Although the average change in scores from pre-test to post-test was positive for experimental students (+.24) and negative for control students (–.39), the average positive change in scores for experimental students was not statistically significant (Table 1).[4] We suspect that this is a function of our use of an average change in scores, which likely masks how contextualization impacts "some students" more than others.

Lastly, we examine if contextualizing developmental math content into Introduction to Sociology positively affected student outcomes in their developmental math course (Elementary Algebra), as measured by their performance on the CEAFE. In the spring 2016 semester, only 14 students from each group were enrolled in Elementary Algebra at the same time that they were enrolled in Introduction to Sociology. Based on the post-test evidence, a 1-Tailed T-Test was used to analyze whether the 14 experimental students performed better than the 14 control students on the CEAFE at the end of the semester. Experimental students answered an average of 3.5 more of the exam's 25 questions correctly than did the control students (Table 1). Also of consequence, the lowest CEAFE score earned by experimental students exceeded that of control students by 24 points (6 more correct answers). Considering that the project's math content is only directly relevant to 7-8 questions on the exam, this may indicate that contextualization had an impact beyond the specific topics and skills that were covered. Given the sample size for this analysis, more investigation is required.

Finally, given the availability of students' responses to individual CEAFE questions, it was also possible to independently examine the same students' scores on the five CEAFE

questions that corresponded to the five questions on the pre-/post-tests. On average, experimental students answered more than four out of these five questions correctly (Table 1). Additionally, experimental students answered approximately .78/5 more questions correctly than did control students (16.86/20=4.215/5 and 13.71/20=3.43/5). Again, given the sample size for this analysis, additional investigation is required.

DISCUSSION

In general, the contextualization of developmental math content into other courses seems to have a positive impact on some students' grasp of discrete mathematical skills and success in developmental math. More specifically, using elementary algebra to reinforce the learning outcomes of Introduction to Sociology seems to have had a positive impact on experimental students' scores on a post-test instrument designed to gauge their mathematics learning: while control students' scores *decreased* from the pre-test to the post-test, experimental students' scores *increased* from the pre-test to the post-test. Likewise, there was a statistically significant difference between the experimental and the control students' average scores on the CEAFE, with experimental students both earning the higher average score on the 25-question exam and outperforming control students on the five CEAFE questions that aligned with the pre-/post-tests.

Limitations and Considerations

Unfolding over a single semester, this study engaged a relatively small sample across two community college campuses in the United States. While the study seems to support the contextualization of developmental math content into courses like Introduction to Sociology, it does have four limitations. First, due to the small number of participants concurrently enrolled in

an experimental section of Introduction to Sociology and an Elementary Algebra course, it is neither possible nor responsible to make a definitive statement about the relationship between contextualization and students' success in developmental math. Second, given the role that students' confidence plays in their math performance (see, for example, Chemers, Hu, and Garcia 2001), this and other potential mediating variables require attention in future studies of contextualization. Third, while this study unfolded across two distinct community college campuses, no claims regarding its replicability can or should be made; factors like instructor and/or student characteristics may impact contextualization at other institutions. Fourth, given students' struggles in and resistance to math, it is unreasonable to expect dramatic results from contextualization in one course in a single semester. This is particularly true in community college contexts, where most students have experienced low levels of success in math. Thus, future research should consider larger studies involving more instructors, campuses, and semesters, and this research should also include a qualitative component aimed at exploring the processes by which contextualization impacts students' learning/success and their impressions/understanding of sociology. Careful attention might be paid to those students who do not complete the course and/or those students who choose not to participate in the study, as well.

Also worthy of consideration are the challenges that the three authors faced when developing the project's modules. While all three modules proved informative and successful, their creation revealed how little of the Elementary Algebra curriculum is relevant to the quantitative work of sociology. In other words, while it was encouraging that the modules seemed to impact experimental students' algebraic skills, it was distressing to discover how

much of the Elementary Algebra curriculum—including radicals, factoring expressions, and quadratic equations—is difficult to integrate into a social science or humanities course.

This realization raises questions about what math skills are critical to student success in non-STEM courses and majors. Institutionally, through the creation of algebra prerequisites, math departments have implicitly taken the lead in defining the math skills necessary for success in other fields. For example, at CUNY, Elementary Algebra is currently a hurdle to sociology students' more relevant statistics coursework. Thus, the current study contributes to larger national conversations about both the skills required of students in the social sciences (e.g., Kalamkarian, Raufman, and Edgecombe 2015) and alternative pathways to math success (e.g., CUNY Taskforce on Developmental Education 2016). Sociologists must continue to contribute to these important discussions.

Conclusions and Contributions

Across community colleges in the United States, most students place into a developmental math course that they never pass. This can deprive them of the math skills necessary to make informed decisions in major areas of social life and the college credential required for participation in growing sectors of our economy. One strategy for improving community college students' pass rate in developmental math is the contextualization of developmental math content into the fabric of courses like Introduction to Sociology. This article reviewed one effort to contextualize elementary algebra into three modules of the Introduction to Sociology course at CUNY's KBCC and QCC during the spring 2016 semester. Data from a pre-test/post-test control-group design implemented across the two campuses provide initial evidence of the efficacy of this strategy; suggesting that the contextualization of developmental math content into Introduction

to Sociology promotes some sociology students' grasp of discrete mathematical skills and success in developmental math.

While contextualization seems to be a promising strategy for developmental math as it is currently organized, this study also points to the challenges of contextualization and to faults in developmental sequences that require Elementary Algebra instead of, or for placement in, more relevant statistics courses. Thus, this study leads to two potentially conflicting recommendations in the effort to improve developmental math for community college students. The first builds on the initial evidence of this study by recommending improvements to contextualization: redefine and extend the module approach for deeper implementation in Introduction to Sociology; explore replication models within other social science and humanities courses so that students 'do math' across the curriculum; and develop more finely-tuned assessments and qualitative strategies to capture the underlying challenges and processes of students' math learning in context. The second recommendation urges the reconsideration of the developmental math sequence for community college students, who might benefit more from statistics coursework.

This study also points to several significant directions for sociology instruction. Students who place into developmental math can, and should, be encouraged to co-register for an Introduction to Sociology course that contextualizes math; students' developmental needs are not a barrier to their success in the course, and this registration stands to strengthen their math skills. Likewise, in incorporating math as a decision-making tool, sociology instructors can engage students with a problem-posing pedagogy that connects the sociological imagination to contemporary social problems. To this point, modules similar to the ones described above can also be developed for upper-level courses within the discipline, such as Social Problems, Sociology of Deviance, Urban Sociology, and the Sociology of Religion.

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AUTHORS' NOTES

1. At QCC, instructors using the OER textbook *MyMathGPS: Elementary Algebra Guided Problem Solving* (Cornick, Guy, and Puri 2015) and its associated pedagogy have seen significant improvements in student pass rates in Elementary Algebra (including the CEAFE) (Guy, Cornick, and Puri 2016).

2. Modules will gladly be shared upon request.

3. Given that students in the experimental and control sections differ in both their need to enroll in Elementary Algebra and the timing of that enrollment, it is important to note that the study sample varies according to research question, instrument of measure, and method of analysis.

4. While outside of the bounds of this study, it is interesting that the average change in scores from pre-test to post-test for control students was negative *and* statistically significant. This might indicate that, for some students (particularly those who had enrolled in Elementary Algebra prior to spring 2016), distance from regular exposure to algebra leads to diminished performance on the aligned skills.

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race/ethnicity, gender, adoption, and (dis)abilities in contemporary American families and educational institutions. She has published articles on these topics in such venues as *Qualitative Inquiry, Qualitative Sociology*, *Sociological Focus*, *International Journal of Sociology of the Family,* and *The Journal of Education Policy*. Traver is also interested in community college pedagogies. She is the co-editor (with Zivah Perel Katz) of *Service Learning at the American Community College: Theoretical and Empirical Perspectives* (Palgrave Macmillan 2014).

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Table 1. Results from Paired and Welch Two-Sample T-Tests

	Experimental Group	Control Group	N (experimental/ control)
All Participants			
Mean Pre-Test Score[1]	3.21/5	3.00/5	70/86
Mean Post-Test Score[1]	3.44/5**	2.70/5**	63/69
Mean Change from Pre-Test to Post-Test[2]	+.24	–.39*	58/59
Participants Concurrently Enrolled in Elementary Algebra			
Mean CEAFE Score[3]	74.3/100*	60.6/100*	14/14
Mean Score on Five CEAFE Questions[3]	16.86/20*	13.71/20*	14/14

* $p<.05$
** $p<.01$
[1] Welch Two-Sample T-Test
[2] Paired T-Test
[3] Welch Two-Sample 1-tailed T-Test