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How Successful Is The Emporium Model In Developmental Mathematics? - A Quantitative Study of Gateway Mathematics Student Success Rates

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David Wang

Prof./Dr./Chair, Department of Math and Computer Sciences, Mercy College, New York, USA

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ABSTRACT

Since the turn of the 21st century, the emporium model has become a popular choice for colleges and universities to reform developmental mathematics. The purpose of this study is to determine overall how successful Northeast Metro College (NMC)'s emporium developmental mathematics program is as compared to its traditional lecture-based program by comparing these two programs' student success rates in gateway courses. This study would address the following research question: are there any differences in gateway mathematics success rates for three groups: students who took their last required developmental course using the emporium model, those who enrolled in their last required developmental course taught in the traditional lecture-based model, and college-ready students? This research is a non-experimental, secondary data quantitative analysis study with nonrandom convenience samples.

1. INTRODUCTION

In 1849, the University of Wisconsin launched the nation's first formal college preparatory program (Cafarella, 2014). The program provided remedial courses in reading, writing, and arithmetic for underprepared students (Brier, 1986). "By the 1940s, the college preparatory program had been largely replaced as a fixture in American higher education by junior colleges and college divisions within universities" (Boylan, 1988, p. 2). In the early 1970s the term "developmental education" was established and was increasingly and widely used as there was a national focus on student preparation for college readiness (Arendale, 2002; Boylan & Bonham, 2007).

Globalization and domestic workforce competition demand future employees, and our students, be equipped with competent writing, reading, and mathematics skills (World Economic Forum, 2016). Developmental education is designed to prepare student readiness for college in those competencies. However, the outcome of developmental education is dismal (Jaggars & Stacey, 2014) and the majority of developmental students are not able to fulfill their remediation requirements (Chen, 2016), and stakeholders are calling for national actions to reform developmental education.

Developmental education is increasingly the center of the national debate in higher education, especially developmental mathematics, which has a much lower pass rate in comparison to developmental English (Bonham & Boylan, 2011). Approximately half of the developmental mathematics students fail to complete the courses, and this high failure rate is a barrier to college completion (Davis, 2014). Enrollment in developmental mathematics not only costs students money but also delays their graduation. With pressure from all stakeholders, colleges are carrying out innovative ways to improve the pass rate in developmental mathematics.

Since the turn of the 21st century, the emporium model has become a popular choice for universities and colleges to reform developmental mathematics. The emporium model, named after its originator, Virginia Tech (Virginia Polytechnic Institute and State University) which called its initial course redesign (National Center for Academic Transformation, n.d.), intends to address the challenges facing the traditional lecture-based model. It is composed of several core components and much of the detailed implementations have been left to colleges. That means the redesigned emporium developmental mathematics programs can vary from one institution to another, and sometimes these programs can differ considerably.

2. THE EMPORIUM MODEL AT NMC

Northeast Metro College (NMC), located in New York City metropolitan area, with an enrollment of approximately 8,000 full-time students and 6,000 part-time students at three campuses. Almost two-thirds of NMC first-year, first-time students take at least one remedial course. In Fall 2014, after experiencing some promising outcomes from several pilot programs aiming to improve developmental mathematics, NMC began to implement the emporium model for all existing developmental mathematics courses. Simultaneously NMC is running traditional lecture-based developmental mathematics courses. All gateway courses are traditional lecture-based. NMC focused on a self-paced computer-based mastery method to implement the emporium model. How does self-paced computer-based mastery method work? After the Accuplacer test, remediation students have their free choice to enroll in the traditional course(s) or the self-paced computer-based mastery course(s). The emporium classes meet twice a week with the same professor at a learning computer hub center which has 48 student stations and accommodates two class sections of 24 each with two professors and two student tutors. After class time, students can go to a large annex center with 24 student stations for dropping-ins and separate testing. The annex center opens six days a week and is staffed by at least two full-time supervisors. Students watch videos related to each homework assignment, to begin with, complete notes related to each video, and achieve a level of mastery on each assignment. Students can work at their own pace and may retake tests to improve their score. Knowledge and concepts are organized into modules. Students watch a video of a particular model first and then review video notes. During class time, professors and tutors stand by to answer an on-demand individual request for assistance. Students then do warming-up exercises and homework and take the test whenever they feel ready. All student computer activities can be monitored by professors and tutors. So even if students do not ask questions and if the monitored computer activities indicate students are stuck in certain assignments, professors and tutors can proactively come to students to assist. Immediately students will receive feedback on tests and homework. Students only will be allowed to move to the next module if they successfully pass the test of the current module with a score of at least 70% (mastery method). Students have the opportunity to progress more quickly (or slowly) with the help of courseware, My MathLab, and they gain flexible scheduling accommodations. There are cost savings for students in this model. Students can complete more than one developmental mathematics course in one semester if motivated. Students can begin the next semester where they left off. Students can adjust their schedules to suit life changes.

What are the differences between a "self-paced" class and a "traditional" class? The self-paced mastery program provides students with the opportunity to go through a course "at their own pace" instead of being controlled by the pace of the teacher in the traditional mathematics lecture time. In the self-paced computer labs staffed by professors and professional and peer tutors, students work on computer-based activities. Students spend the bulk of their course time doing mathematics problems rather than listening to a traditional mathematics lecture. Advantages of the self-paced program are that: accommodates different learning styles; offers both videos and power points; offers on-demand individual assistance; provides immediate feedback on tests and homework; allows progressing more quickly and completing two classes in one semester, and enables the students to become independent learners.

Students are placed into relevant remedial mathematics courses, as shown in Table 1, as per their Accuplacer test scores which are based on 120 points.

Table 1: Accuplacer Placement

Arithmetic Placement Scores	
0-29	DM1 - Basic Mathematics Linked Support and DM2 - Basic Mathematics must be taken together.
30-59	DM2 - Basic Mathematics
60–76	DM3 - Accelerated Basic Mathematics
Algebra Placement Scores	
0-75	DM4 - Algebra for Liberal Arts (planning to take MAT101, MAT102 and/or MAT103)
0-75	DM6 - Algebra (planning to take MAT104 and beyond, STEM, Nursing, or Business majors)

To enroll in a gateway mathematics course, students must demonstrate proficiency in basic mathematics and elementary algebra. Students may enroll in any of the following gateway mathematics courses: MAT101 - Contemporary Mathematics; MAT102 - Statistics I; MAT103 - Finite Mathematics; MAT104 - Intermediate Algebra. MAT101, MAT102, and MAT103 are general education courses. These courses may be used to satisfy the mathematics general education requirement. MAT104 is not a general education course and thus cannot be used to satisfy this degree requirement.

3. METHODOLOGY

The purpose of this study is to determine overall how successful NMC's emporium developmental mathematics program is as compared to its traditional lecture-based program by comparing these two programs' student success rates in gateway courses. The success rate is defined as the percentage of students succeeding in a class with a minimum of a C grade (NMC has a D grade in gateway mathematics courses). Therefore, this study would address the following research question and Hypothesis:

R1. Are there any differences in gateway mathematics success rates for three groups: students who took their last required developmental course using the emporium model, those who enrolled in their last required developmental course taught in the traditional lecture-based model, and college-ready students?

H1. There are statistically significant differences in gateway mathematics success rates for three groups: students who took their last required developmental course using the emporium model, those who enrolled in their last required developmental course taught in the traditional lecture-based model, and college-ready students.

Type of research. Because of the availability of existing data and no requirement for experimental treatments, this research was a non-experimental, secondary data quantitative analysis study with nonrandom convenience samples. There is not a single best way to determine an academic program's success or failure. However, the success rate is deemed as one of the most effective and feasible assessment indicators. By examining the success, this study applied several statistical analyses to validate the findings.

Population and Sample. The population was all NMC's gateway mathematics students (at least 18 years old at the time of enrollment). The sample was any student who took at least one gateway mathematics course in any of the fall or spring semesters of 2016–17 or 2017–18. Students could take different gateway mathematics courses as well as repeat them during the four semesters included in the study. Gateway mathematics courses were MAT101 - Contemporary Mathematics, MAT102 - Statistics I, MAT103 - Finite Mathematics, and MAT104 - Intermediate Algebra.

Data Collection. Final course grades of gateway mathematics in the fall and spring semesters of 2016 – 2017 and 2017 – 2018 were collected for NMC students (at least 18 years old at the time of enrollment) along with their pre-gateway mathematics status (emporium developmental, traditional developmental, or college-ready). No student identifiers were in the data set. The enrollment data of gateway mathematics courses in the fall and spring semesters of 2016 – 2017 and 2017 – 2018 were shown in Table 2.

Table 2: Gateway Math Enrollment 2016 – 2018

	Traditional Lecture-based Classes Only
Fall 16	2192
Spring 17	2064
Fall 17	2023
Spring 18	1650
Total	7929

Data Analysis. IBM's SPSS Statistics was used to conduct all calculations and various data analyses. SPSS (Statistical Package for the Social Sciences) is a software package used for interactive and statistical analysis. Originally developed by SPSS Inc., it was acquired by IBM in 2009 and renamed IBM SPSS Statistics (IBM, n.d.). Excel macros and functions were used to confirm the calculations and statistical analysis done by SPSS. The researcher calculated the success rates of gateway mathematics of various student groups studied for fall 2016, spring 2017, fall 2017, and spring 2018. Chi-square tests of goodness-of-fit were performed to further analyze whether there was a significant difference in success rates of different student groups. Because of its easiness of construction and reliability, the Chi-square test is frequently used to determine whether there is a significant difference between the expected values and the observed values in one or more variables among groups (Johnson & Christensen, 2014). Chi-square (x^2) with a (the level of significance) set at 0.05. If p (possibility of occurrence) < 0.05, the researcher would reject the null hypothesis that no significant difference is among groups and thus, would confirm the proposed hypothesis that significant difference is among groups. On the other hand, if p > 0.05, the researcher would accept the null hypothesis without enough evidence to support the proposed hypothesis. If p = 0.05, the researcher would neither confirm nor reject the proposed and null hypotheses.

4. RESULTS

Table 3: Gateway Mathematics Success Rates

	Emporium Dev Math			Traditional Dev Math			College-ready				
	S	Total	SR	S	Total	SR	S	Total	SR	x^2	*P*
Fall 16	157	290	54%	369	675	55%	762	1227	62%	12.88	0.002*
Spring 17	124	275	45%	332	653	51%	642	1136	57%	13.73	0.001*
Fall 17	157	302	52%	335	623	54%	659	1098	60%	9.81	0.007*
Spring 18	112	245	46%	271	519	52%	520	886	59%	14.97	0.001*

Note. * indicates significant difference as $p < 0.05$. S - Success. SR - Success Rate. Success rate is defined as percentage of students succeeding a class with a minimum of C grade (NMC has D grade in gateway mathematics courses).

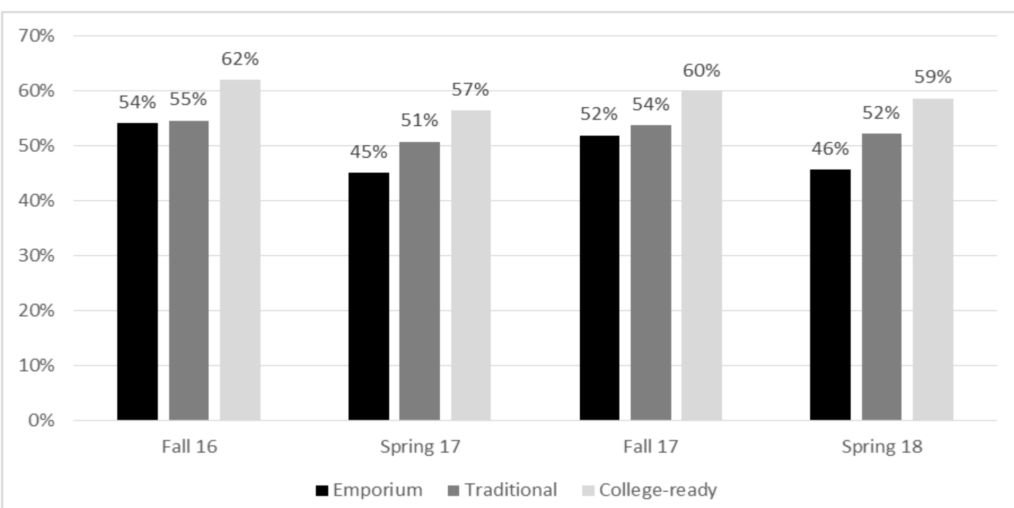

Figure 1. Gateway mathematics success rates.

There are differences in gateway mathematics success rates for three student groups (see Table 3 and Figure 1). For each semester, the college-ready success rate has been higher than the traditional success rate which surpassed the emporium success rate.

Over four semesters studied, all *p*s < 0.05 assert that the success rates in the three student groups (emporium, traditional, and college-ready) were affirmatively contingent upon the type of developmental mathematic models students enrolled (if any) and the college-ready qualification (if any). Thus, the researcher confirmed H1 and rejected its null hypothesis. The college-ready success rate was highest, the traditional success rate ranked second, and the emporium success rate placed last. These gaps were statistically significant.

In summary, the gateway mathematics success rate for all college-ready students was higher than that for all students who took their last required developmental course taught in the traditional lectured-based model, and the latter was higher than the gateway mathematics success rate for all students who enrolled in their last required developmental course using the emporium model. These gaps were statistically significant.

5. DISCUSSIONS AND CONCLUSION

Limitations of the Study. The study assumes that the prior mathematics levels of emporium students and those of traditional students were not significantly different. There is no guarantee for this assumption. As in any non-experimental study, the researcher would not be able to control, manipulate or change part of the experiment (Johnson & Christensen, 2014). Instead, the researcher would rely on existing student records to conclude. Thus, the data obtained from NMC are assumed to be in a good state and have been verified. To enroll in emporium developmental mathematics courses, students had to agree with the self-paced computer-based setting. Students might not be used to this type of learning environment. The period studied was limited to two academic years because the emporium program was only launched a few years ago. Instructors and students might have biases (positive and/or negative) about the emporium classes. The researcher also acknowledges that the findings of the study may not be conclusive for colleges of different characteristics for their developmental mathematics populations.

Recommendations. Currently, all gateway mathematics courses are traditional lecture-based. After emporium students complete developmental courses, one would argue that they likely prefer to enroll in emporium gateway courses. The researcher recommends the offerings of a few emporium sections for each gateway course as a starter. Then research the emporium model for both developmental and gateway classes. The future study would find more conclusive and convincing results.

Future Research. The current study was quantitative research and it is crucial to get student, staff and faculty points of view regarding the emporium model. Mixed-method research would produce more insightful and comprehensive findings. The researcher would replicate the study by incorporating interviews and surveys to get qualitative data from developmental mathematics students, staff and faculty.

College-ready students outperformed any type of developmental students in gateway classes. This indicates mathematics remediations regardless of instruction types do not develop students in need of remediation to perform at a similar mathematics level as their college-ready counterparts. There is much to be researched to improve all instruction types in developmental mathematics.

Traditional lecture-based classes equipped developmental students for success in gateway mathematics better than emporium classes, considering that currently no emporium gateway mathematics classes are offered at NMC. Why did this seemly contradictory occur? Without any concrete research for this question, one could argue that this outcome might have something to do with the learning style of students. Emporium students passed developmental courses and then enrolled in traditional lecture-based gateway courses. They may be used to the emporium learning environment and in gateway courses they had to adjust to a new learning style. If their transformation did not go well, the success rate would be adversely impacted. The study can be also improved by collecting and analyzing emporium gateway student data after NMC offers emporium gateway classes.

CONCLUSION

Traditional lecture-based classes equipped developmental students for success in gateway mathematics better than emporium classes, considering that currently no emporium gateway mathematics classes are offered at NMC. The gateway mathematics success rate for all college-ready students was higher than that for all students who took their last required developmental course taught in the traditional lectured-based model, and the latter was higher than the gateway mathematics success rate for all students who enrolled in their last required developmental course using the emporium model. These gaps were statistically significant.

The need to study the emporium model in developmental mathematics is urgent as more students arrive at colleges academically underprepared in mathematics (Jaggars & Stacey, 2014). The emporium model is rather a new and innovative instruction method applying technologies. The "One size fits all" approach does not work. After initial implementations, each college should collect and analyze its data to determine if appropriate steps are being executed and if necessary, additional operations are to be implemented.

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