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A Comparative Study of Developmental Mathematics Pass Rates for Two Student Groups: Emporium Classes and Traditional Lecture-based Classes

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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 pass rates in developmental courses. This research is a non-experimental, secondary data quantitative analysis study with nonrandom convenience samples. The findings indicate that generally emporium classes prepare students for passing developmental mathematics more successfully than traditional lecture-based classes do.*

Keywords— ***Developmental mathematics, Emporium model, Pass rates.***

I. INTRODUCTION

Globalization and domestic workforce competition demand future employees, our students, be equipped with competent writing, reading, and mathematics skills [1]. Developmental education is designed to prepare student readiness for college in those competencies. However, the outcome of developmental education is dismal [2] that the majority of developmental students are not able to fulfill their remediation requirements [3], 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 much lower pass rate in comparison to developmental English's [4]. Approximately half of developmental mathematics students fail to complete the courses, and this high failure rate is a barrier to college completion [5]. With the pressure from all stakeholders, colleges are carrying out innovative ways to improve the pass rate in developmental mathematics.

Enrollment in developmental mathematics not only costs students' money but also delays their graduation. 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 [6], 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.

II. THE EMPORIUM MODEL AT NMC

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 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 in 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 are able to work at their own pace and may retake tests to improve their score. Knowledge and concepts are organized into modules. Students watch video of a particular model first and then review video notes. During class time, professors and tutors stand by to answer on-demand individual request for assistances. 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 at least 70% (mastery method). Students have the opportunity to progress more quickly (or slowly) with the help of courseware, MyMathLab, and they gain flexible scheduling accommodations. There are cost savings for students in this model. Students are able to complete more than one developmental mathematics course in one semester if motivated. Students are able to begin the next semester where they left off. Students can adjust schedule 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: accommodates different learning styles; offers both videos and power points; offers on-demand individual assistance; provides immediate feedback on tests and homework; affords the opportunity to progress more quickly and complete 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)

In order 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.

III. 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 pass rates in developmental courses. Therefore, this study would address the following research question and Hypothesis: **R1**. Is there a difference in developmental mathematics pass rates for two groups: students in the emporium classes and those in the traditional lecture-based classes?

H1. There is a statistically significant difference in developmental mathematics pass rates for two groups: students in the emporium classes and those in the traditional lecture-based classes.

Type of research. Because of the availability of existing data and no requirement of 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, pass rate is deemed as one of the most effective and feasible assessment indicators. By examining the pass rates, this study applied several statistical analyses to validate the findings.

Population and Sample. The population were all NMC's developmental students (at least 18 years old at the time of enrollment). The sample was any student who took at least one developmental mathematics course in any of the fall or spring semesters of 2016–17 or 2017–18. Students could take different developmental mathematics courses as well as repeat them during the four semesters included in the study. Developmental mathematics courses included DM2 - Basic Mathematics, DM3 - Accelerated Basic Mathematics, DM4 - Algebra for Liberal Arts, DM5 - Algebra Topics, and DM6 – Algebra.

Data Collection. Final course grades of development mathematics (DM2, DM3, DM4, DM5, and DM6) 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). No student identifiers were in the data set. The enrollment data of developmental mathematics courses in the fall and spring semesters of 2016 – 2017 and 2017 – 2018 were shown in Table 2. Combining the four semesters, there were a total enrollment of 8061 in developmental mathematics. Approximately one out of four developmental mathematics students took emporium classes.

Table 2: Developmental Math Enrollment 2016 – 2018

	Emporium Program	Traditional Program
Fall 16	586	2056
Spring 17	547	1462
Fall 17	439	1523
Spring 18	343	1105
Total	1915	6146

Data Analysis. IBM's SPSS Statistics was used to conduct all calculations and various data analysis. 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 as IBM SPSS Statistics [7]. Excel macros and functions were used to confirm the calculations and statistical analysis done by SPSS. The researcher calculated pass rates of developmental 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 pass rates between student groups. Because of its easiness of construction and its 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 [8]. 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 between or among groups and thus, would confirm the proposed hypothesis that significant difference is between or 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. To answer **R1**, first the researcher calculated the developmental mathematics pass rate for each group in each semester: students in the emporium classes and those in the traditional lecture-based classes. Second a Chi-square test was used to further analyze if there was a significant difference between the pass rates of these two student groups in each semester. Lastly, the researcher compared numerically the two groups' pass rates. **H1** was then tested. If at least three of four semesters' ps < 0.05, the researcher would confirm **H1** and reject its null hypothesis. Otherwise, the researcher would reject **H1** and accept its null hypothesis.

IV. FINDINGS

Table 3: Developmental Mathematics Pass Rates

	Emporium			Traditional					
	Pass	Total	Pass Rate	Pass	Total	Pass Rate	E PassRate – T PassRate	x^2	*p*
Fall 16	378	586	65%	1223	2056	59%	6%	4.81	0.028*
Spring 17	350	547	64%	823	1462	56%	8%	9.70	0.002*
Fall 17	268	439	61%	825	1523	54%	7%	6.53	0.011*
Spring 18	197	343	57%	622	1105	56%	1%	0.14	0.709

Note. * indicates significant difference as p < 0.05. Pass rate is defined as percentage of students passing a class with a minimum of C grade (NMC does not have D grade in developmental mathematics courses).

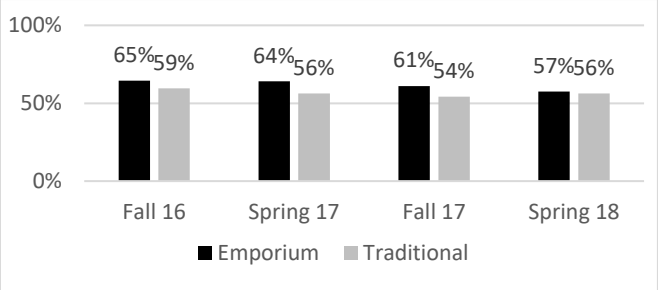

Fig. 1: Developmental mathematics pass rates.

There is a difference in developmental mathematics pass rates for two groups: students in the emporium classes and those in the traditional lecture-based classes (see Table 3 and Figure 1). For each semester, the emporium pass rate has been higher than the traditional pass rate. A Chi-square test of goodness-of-fit was performed to determine whether there was a significant difference in pass rates between emporium and traditional students. Over the period of two years studied, with the exception for spring 2018, all ps < 0.05 assert that there was a significant difference in pass rates between emporium and traditional students and that the pass rates in the two groups were affirmatively contingent upon the type of developmental mathematic models students enrolled. With emporium students significantly outperforming traditional students in three of the four semesters, the researcher confirmed H1 and rejected its null hypothesis. Developmental mathematics pass rate for students in the emporium classes was higher (statistically significant) than that for students in the traditional lecture-based classes and the researcher concluded that generally emporium classes prepared students for passing developmental mathematics more successfully than traditional lecture-based classes did.

V. DISCUSSIONS AND CONCLUSION

Limitations of the Study. While comparing pass rates for the two student groups (emporium and traditional), the study assumes that the prior mathematics levels of emporium students and those in the traditional students were not significantly different. There is no guarantee for this assumption. As in any non-experimental studies, the researcher would not be able to control, manipulate or change part of the experiment [8]. Instead, the researcher would rely on existing student records to draw the conclusion. Thus, the data obtained from NMC are assumed to be in the 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 time 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 math courses are traditional lectured-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 conduct a research on 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 a quantitative research and it is crucial to get student, staff and faculty points of views regarding the emporium model. A mixed-method research would produce more insightful and comprehensive findings. The researcher would replicate the study incorporating interviews and surveys to get qualitative data from developmental mathematics students, staff and faculty. The study can be also improved by collecting and analyzing emporium gateway student data after NMC offers emporium gateway classes.

Conclusion. Overall, NMC has implemented a very successful emporium developmental mathematics program. Emporium classes prepared students for passing developmental mathematics more effectively than traditional lecture-based classes. The need to study the emporium model in developmental mathematics is urgent as more students arrive at colleges academically underprepared in mathematics [2]. The emporium model is rather a new and innovative instruction method applying technologies. “One size fits all” approach does not work. After initial implementations, each college should collect and analyze its own data to determine if appropriate steps are being executed and if necessary, additional operations are to be implemented.

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