

# RevUp: Empowering Montana's Workforce

## Developmental Math Study Report

*Prepared under contract to*  
Great Falls College Montana State University

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## Introduction

Montana's RevUp project included 13 of the state's two-year colleges in a four-year project to enhance student services and college programs in technical fields funded by the U.S. Department of Labor (DOL) through the Trade Adjustment Assistance Community College and Career Training (TAACCCT 3) grant program. One component of RevUp team was improvements in college math instruction. Three of the colleges introduced changes to their developmental math programs, and the other colleges enhanced technical math instruction to ensure that the information taught corresponded to what the students need to succeed in their technical education programs and fit the needs of employers.

The RevUp consortium engaged RTI International to evaluate and collect data on the redesign of manufacturing and energy programs, student services implemented under the grant, and grant-funded activities to support apprenticeship and sector strategy initiatives. This report presents the results of a quasi-experimental analysis of the effects of adopting an emporium model for developmental math programs on educational outcomes for students in those programs. Using a newly renovated math lab, the college and university redesigned their developmental math program to offer computer-based self-paced learning. The new program replaced four hours of class-based instruction per week with one 50-minute class meeting and four hours of required lab time, during which instructors and coaches are available to help. Although the developmental math program is based at Missoula College (MC), it also serves students who attend the University of Montana, Missoula (UM).

Owing to data limitations, the RTI was not able to estimate the effective of changes on student outcomes: The most recent available data for the study were from fall term 2016, a year after implementation of the emporium math program, too early to analyze students' completion of their development math sequences, enrollment in college math course, and credential attainment<sup>1</sup>. In addition, the data did not indicate the term in which the students' math courses were taken. As a result, the analysis could not determine whether students completed their developmental or college math sequences within the one-year time frame.

Accordingly, the student outcomes examined in this analysis were limited to a before and after program implementation comparison of (1) students' average cumulative grade point average (GPA), (2) credit accrual during the first year of enrollment, and (3) program enrollment at the end of the year. In addition to the limited time frame of the available data, the analysis was also limited by a small sample size, relatively few student characteristics to

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<sup>1</sup> Two years is a more typical time frame for student completion/degree attainment in a community college setting.

use in matching, and the potential intervention of external factors not captured in the analytical model; these limitations may be mitigated by incorporating additional (and more recent) data into the analysis. RTI has an outstanding data request with the MC institutional research office to access the data needed for a more robust analysis on the program's effects. Should the institutional research office be able to provide the additional data by mid-November, RTI will update this study and resubmit this report before the end of the 2017 calendar year. The primary goal of this report is to provide a model for future analyses of the Developmental Math program once two or more years of data on students in the redesigned program are available.

Researchers from RTI International (“the evaluation team”) assessed the impact of changes to the developmental math program on student performance and outcomes. The institutional research office for the institutions provided data on students enrolled in the developmental math program from fall term 2009 through fall term 2016. The changes under consideration were the adoption of a technology-enabled “emporium” model of developmental math instruction, as well as the provision of a math lab space, which were fully implemented in fall 2015.

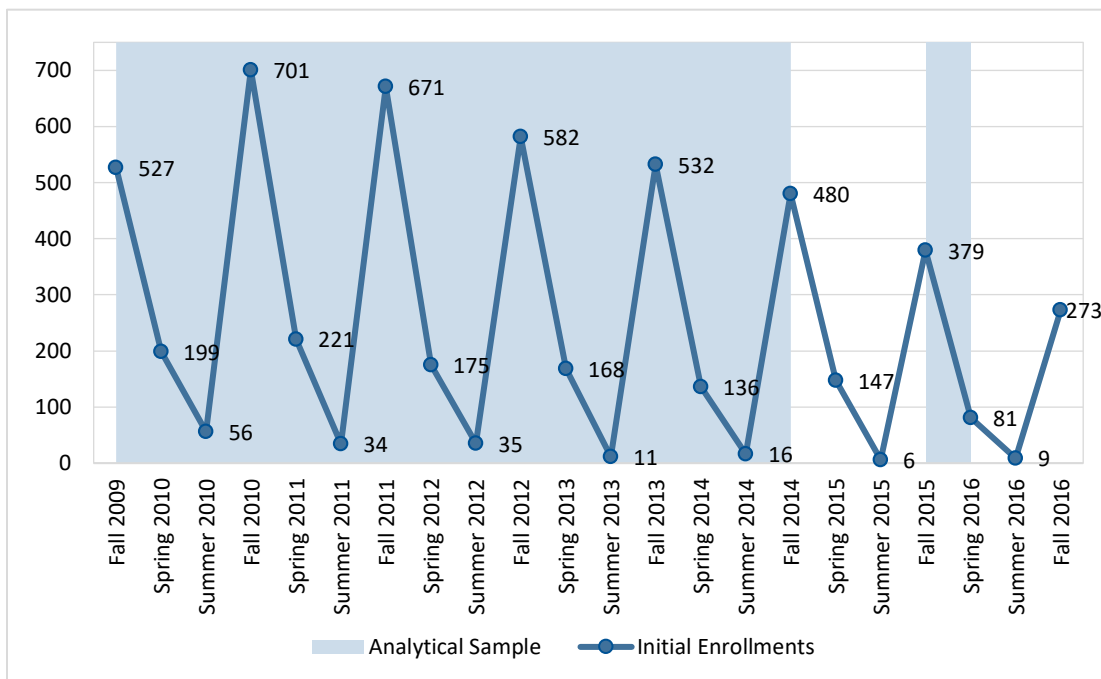
The analysis compared student outcomes of cohorts that enrolled in developmental math coursework before (“the comparison group”) and after (“the treatment group”) fall 2015. The evaluation team employed a propensity score-based weighting strategy to ensure that demographic and enrollment characteristics of the comparison group resembled those of the treatment group and control for confounding, pre-treatment factors that may influence student outcomes apart from changes to the developmental math program. By comparing comparison and treatment cohorts in terms of (1) average GPA, (2) credit accrual in the first year of enrollment, and (3) program enrollment at the end of the year, the analysis sought to determine the effects of the restructured developmental math program on student educational outcomes for 4-year degree students at UM and less-than-4-year degree or certificate students at MC.

## Data

The institutions' institutional research office provided data on 5,439 students who had taken developmental math courses from fall term 2009 to fall term 2016 at UM (which enrolls 4-year degree students) or MC (which enroll less-than-4-year degree or certificate students). Exhibit 1 shows the number of developmental math students by their initial enrollment term. Although the data did not include information on when students took their development math courses, most take these courses soon after enrolling (i.e., their first and/or second terms).

Due to limitations in available data, the evaluation team elected to assess the outcomes of student outcomes for whom at least a year had passed since their initial enrollment.<sup>2</sup> Accordingly, students first enrolled in summer term 2016 or later were excluded from the analytical sample ( $n=282$ ) because less than a year had passed in the data set since they first enrolled. To avoid treatment crossover, students from the comparison group who were enrolled in spring or summer term 2015 were also excluded ( $n=153$ ). The final analytical sample included 5,004 students: 460 of those were included in the treatment group (9 percent) and 4,544 were included in the comparison group (91 percent).

**Exhibit 1. Term of first enrollment of students who took developmental math courses at the University of Montana, Missoula and Missoula College, fall 2009 through fall 2016**



SOURCE: University of Montana, Missoula, March 2017

Enrollments declined over the study period, reflecting a general decline in enrollments across the University of Montana system (Exhibit 2). The sampled students were predominantly white (77 percent) and about half were female (52 percent). On average they were 23 years old ( $sd=7.7$ ) when initially enrolled in the program. Around 15 percent of students in the sample had a disability, 66 percent were Pell grant recipients, and 18 percent had received a GED. Student had an average of 4-year lapse between high school graduation and postsecondary enrollment ( $sd=7$ ). The average math course placement test score was 2.3

<sup>2</sup> The initial evaluation plan called for evaluation of student outcomes within two-years of initial enrollment; however, data for spring term 2017 were not available at the writing of this report.

with a standard deviation of 0.7, ranging from 1 to 5, but 47 percent of the students did not have the test score or did not take the test before entering the program. Most students (74 percent) were enrolled full time throughout the first year. The student composition at UM mostly mirrored that of the overall sample apart from UM students' higher tendency for full-time enrollment (coefficient=1.4, SE=0.07,  $\chi^2=371.5$ ,  $p<.0001$ ).

The demographic characteristics of students enrolled in the revised, emporium-style developmental math courses (i.e., the treatment group) were similar to those of the comparison group, with exceptions. Pairwise comparisons suggested that students in the treatment group were less likely to be white (coefficient=-.25, SE=0.11,  $\chi^2=4.7$ ,  $p<.05$ ), Pell grant recipients (coefficient=-.25, SE=0.10,  $\chi^2=6.32$ ,  $p<.05$ ), or have received a GED (coefficient=-.35, SE=0.14,  $\chi^2=6.20$ ,  $p<.05$ ) or a math placement test score at the beginning of the program (coefficient=-1.02, SE=0.11,  $\chi^2=85.50$ ,  $p<.0001$ ). They were more likely to be Hispanic (coefficient=.47, SE=0.19,  $\chi^2=6.14$ ,  $p<.05$ ) or attend full-time (coefficient=.32, SE=0.12,  $\chi^2=7.14$ ,  $p<.01$ ). In addition, the treatment group had a shorter lag time than the comparison group between high school graduation and postsecondary attendance (coefficient=-.72, SE=0.34,  $t=-2.12$ ,  $p<.05$ ). These patterns were consistent across the comparison and treatment groups at both UM and MC, except for the absence of the treatment-control difference in postsecondary enrollment after high school.

**Exhibit 2. Enrollment and demographic characteristics of the analytical sample**

	UMM Campus			UTT Campus			All Campuses		
	Treatment (n=256)	Comparison (n=2183)	All (n=2439)	Treatment (n=194)	Comparison (n=2323)	All (n=2517)	Treatment (n=460)	Comparison (n=4544)	All (n=5004)
<b>Demographic Characteristics</b>									
Race/Ethnicity									
American Indian/ Alaska Native	4.7%	4.5%	4.6%	4.1%	5.0%	5.0%	4.3%	4.8%	4.7%
White	73.4%	79.7%	79.0%	75.8%	78.1%	77.9%	74.6%	78.9%	78.5%
Hispanic	6.6%	4.6%	4.8%	8.2%	4.9%	5.1%	7.4%	4.7%	5.0%
Multiracial	5.9%	4.4%	4.5%	2.6%	4.4%	4.3%	4.6%	4.4%	4.4%
Unknown	5.9%	4.4%	4.6%	6.7%	5.5%	5.6%	6.1%	4.9%	5.0%
Other	3.9%	4.0%	4.0%	2.6%	2.1%	2.1%	3.3%	3.0%	3.0%
Female	48.8%	49.4%	49.4%	51.0%	54.8%	54.5%	49.8%	52.2%	52.0%
Age at Initial Enrollment (sd)*	20.6 (4.8)	20.8 (5.2)	20.8 (5.2)	23.4 (7.2)	25.4 (9.2)	25.3 (9.1)	21.9 (6.2)	23.2 (7.9)	23 (7.7)
<b>Enrollment/ Academic Characteristics</b>									
Students with Disabilities	13.3%	15.0%	14.8%	15.5%	14.0%	14.1%	14.3%	14.5%	14.5%
Pell Grant Recipients	51.2%	53.4%	53.2%	72.2%	78.3%	77.9%	60.4%	66.3%	65.7%
Time Lapse Between High School Graduation and Initial Enrollment at University of Montana (sd)**	2.3 (4.6)	2.2 (4.8)	2.2 (4.8)	4.4 (6.6)	5.7 (8.4)	5.6 (8.3)	3.2 (5.7)	4 (7.1)	3.9 (7)
GED	4.7%	7.3%	7.1%	25.3%	28.7%	28.4%	13.7%	18.4%	18.0%
Placement Test Score	2.5 (0.7)	2.6 (0.7)	2.6 (0.7)	2.1 (0.7)	2.1 (0.7)	2.1 (0.7)	2.3 (0.7)	2.3 (2.3)	2.3 (0.7)
Placement Test Score Missing	27.0%	52.8%	50.1%	25.3%	46.5%	44.9%	26.1%	49.4%	47.3%
<b>First-Year Enrollment Intensity</b>									
Always Full Time	89.8%	86.7%	87.0%	66.5%	62.2%	62.6%	79.6%	73.8%	74.4%
Mostly Full Time	5.1%	6.0%	5.9%	11.3%	13.7%	13.5%	8.3%	10.3%	10.1%
Always Part Time	4.7%	7.0%	6.8%	22.2%	22.6%	22.6%	12.0%	15.0%	14.7%
Mostly Part Time	0.4%	0.3%	0.3%	0.0%	1.4%	1.3%	0.2%	0.9%	0.8%

\* From a student's birthdate to the first day of the term when the student was initially enrolled (Jan 15 for Spring, June 15 for Summer, and Sept 15 for Fall).

\*\* From a student's high school graduation date to the first day of the term when the student was initially enrolled (Jan 15 for Spring, June 15 for Summer, and Sept 15 for Fall).

SOURCE: University of Montana, Missoula, March 2017

On average, students had a 2.1 GPA with a standard deviation of 1.3. They earned about 11.9 credits ( $sd = 9.4$ ) over the first year (Exhibit 3). Only two students included in the sample completed a degree or certificate within the first year after enrolling. More than three quarters of the students (78 percent) were still enrolled at the end of the first year. Without removing the potential impact of confounding factors, RevUp students and comparison group students seemed to have similar cumulative GPAs; RevUp students appeared to have higher cumulative credits, and a lower likelihood of remaining in the developmental math program by the end of the first year. The pattern was consistent across UM and MC.

**Exhibit 3. Outcomes by Treatment Condition and Campus**

	University of Montana			Missoula College			Both institutions		
	Treatment	Comparison	All	Treatment	Comparison	All	Treatment	Comparison	All
	(n=256)	(n=2183)	(n=2439)	(n=194)	(n=2323)	(n=2517)	(n=460)	(n=4544)	(n=5004)
One-Year Average GPA	2.3 (1.2)	2.3 (1.1)	2.3 (1.1)	1.9 (1.4)	1.9 (1.4)	1.9 (1.4)	2.1 (1.3)	2.1 (1.3)	2.1 (1.3)
One-Year Credit Accumulation	15.8 (9.7)	14.4 (9.4)	14.6 (9.4)	9.8 (8.8)	9.3 (8.7)	9.3 (8.7)	13.2 (9.7)	11.8 (9.4)	11.9 (9.4)
Enrollment (Still Enrolled at the End of the First Year)	74.6%	86.8%	85.5%	55.2%	71.4%	70.2%	65.9%	78.9%	77.7%
Degree/Certificate Attainment	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%

SOURCE: University of Montana, Missoula, March 2017

## Methods

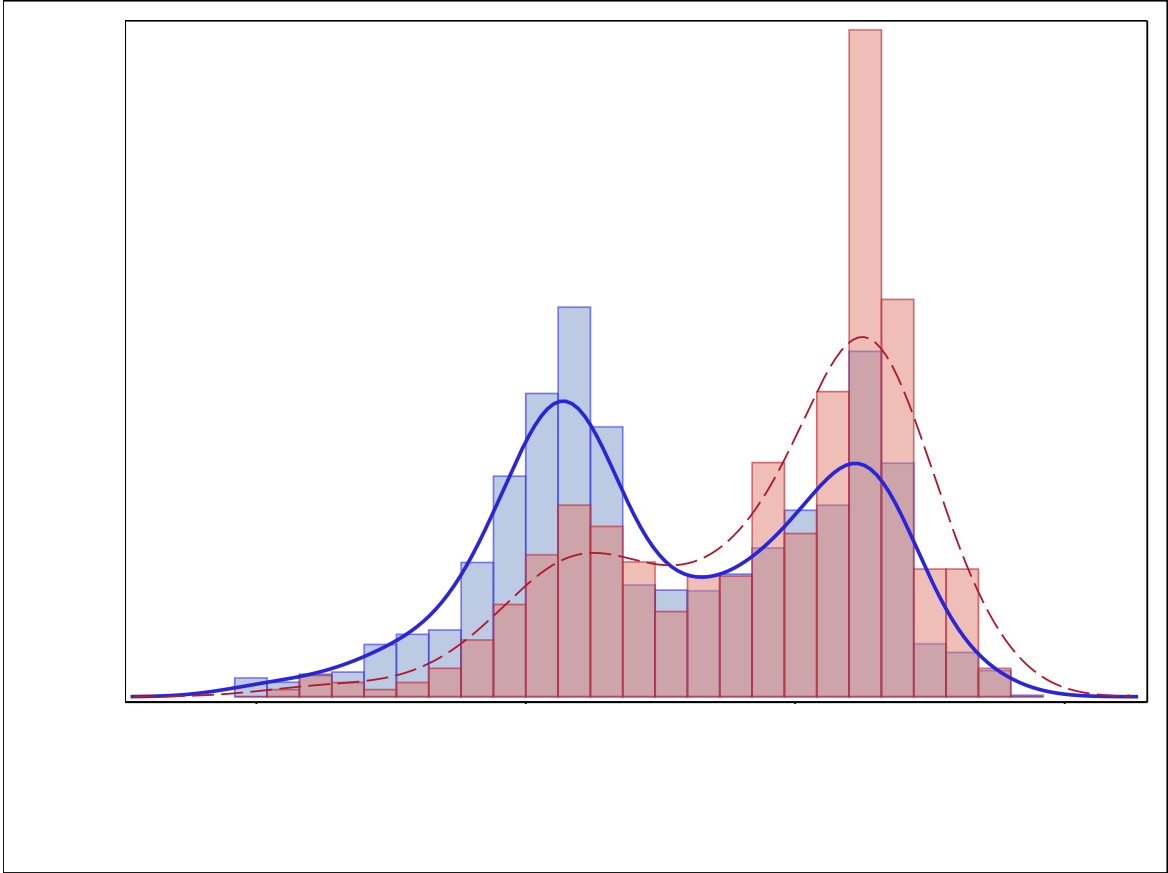
The evaluation team employed the marginal mean weighting through stratification (MMW-S) method, a propensity-score based weighting method to estimate the causal effects of the new math program on student outcomes and to remove potential differences in the demographic and enrollment characteristics of students enrolled in development classes before and after fall 2015. The MMW-S method is a viable solution for evaluating binary treatments such as participation in a developmental math program (Hong and Hong 2009). Unlike PS matching and stratification, MMW-S is appropriate for the analysis of moderating effects such as the program effects by campus. MMW-S uses a nonparametric procedure, making it more robust to potential misspecifications of the functional form of a propensity model than other approaches (Hong 2010).



The first stage of the analysis uses a stepwise logistic regression to identify demographic and enrollment variables that predict any of the outcomes of interest. This step identified 13 significant outcome predictors, including American Indian, White, Female, disability status, age at program entry, GED, math placement test score, missing indicator of the placement score, always full time, mostly full time, always part time, lapse of time between high school graduation and program entry, and UM indicator. The information of these variables is summarized into one unidimensional propensity score and the sample is stratified into five strata based on the distribution of the logit of the propensity score (see Figure 2). A marginal mean weight is computed as the ratio of the number of students in a stratum to the number of treated students in that stratum. Before being adjusted by the marginal mean weight, the RevUp and comparison groups have a group difference of 0.37 (SE=.03,  $t=11.78$ ,  $p<.0001$ ) in the logit of the propensity score. After weighting, the group difference becomes insignificant (Difference=.01, SE=.03,  $t=.35$ ,  $p>.5$ ), which suggests the MMW-S strategy has successfully made the treatment and control groups comparable in observed pretreatment composition; hence any observed differences in outcomes may be attributed to the changes in developmental math program. The marginal mean weight is combined with each of the outcome models for overall program effects. To examine the binary outcomes, i.e. program enrollment, a weighted binary logistic regression model is run with group membership (RevUp vs. comparison) as a predictor and the weight is assigned to students in the analytic sample. To examine GPA or credit attainment, a weighted regression analysis is used.

For analysis of the program effects by institution, the sample is further broken down into two subpopulations (UM vs. UC). The weight was further adjusted to represent the ratio of the number of students in a stratum to the number of treated students in that stratum within each subpopulation. The adjusted weight is combined with each outcome model for subgroup analysis.

**Exhibit 4: Distribution and stratification of the logit of propensity score**



SOURCE: University of Montana, Missoula, March 2017

Note: The stratification further excludes 56 students that have either a zero probability of assigning to one or the other treatment condition or had no match in the other condition.

## Results

The analysis found that students who enrolled after the implementation of the emporium model had the same GPA and accumulated similar course credits over the first year as students who took their developmental math courses prior to RevUp (Exhibit 5). Compared to the historic cohort, students enrolled in the emporium math program were less likely to be still enrolled in the program (coefficient=-.37, SE=.11,  $\chi^2=11.46$   $p<.0001$ ) at the end of the first year. At the institution level, the difference was greatest among students enrolled at UM (coefficient=-.67, SE=.12,  $\chi^2=31.84$ ,  $p<.0001$ ), but was less pronounced at MC.

**Exhibit 5. Weighted Outcome Analysis Results**

	University of Montana			Missoula College			Both institutions		
	Intercept	Estimated Program Effect		Intercept	Estimated Program Effect		Intercept	Estimated Program Effect	
	Coefficient (SE)	Coefficient (SE)	t or Chisq	Coefficient (SE)	Coefficient (SE)	t or Chisq	Coefficient (SE)	Coefficient (SE)	t or Chisq
One-Year									
Average GPA	2.27 (.03)	-.01 (.09)	-.15	1.89 (.03)	.08 (.09)	.93	2.08 (.02)	.03(.06)	0.51
One-Year Credit									
Accumulation	14.60 (.19)	-.24 (.63)	-.38	9.26 (.19)	.35 (.63)	.55	11.94 (.14)	.04 (.46)	.08
Enrollment (Still									
Enrolled at the									
End of the									
First Year)	1.85 (.04)	-.67 (.12)	31.84***	.87 (.03)	-.15 (.11)	1.91	1.29 (.04)	-.37 (.11)	11.46***

SOURCE: University of Montana, Missoula, March 2017  
Coefficient (Standard Error) is presented.

\*p<.05, \*\* p<.001, \*\*\* p<.0001

## Limitations

As is the case with all studies of this type, this study has limitations. Some of the limitations describe below may be addressed once additional data are available should the institutions be interested in expanding this analysis.

1. Program implementation time frame: Because the math lab that is the core component of emporium math programs was not ready until fall 2015, the RevUp developmental math program at Missoula could not be considered implemented prior to that date. However, since implementation is a process that is refined over time, an ideal approach is to test the robustness of the results using different implementation cutoff dates. The National Center for Academic Transformation, for example, recommends a development and implementation time frame of about 18 months (The National Center for Academic Transformation 2013) for emporium-model programs. The data available at the time of this study did not permit this analysis, but RTI recommends this approach for future analyses.
2. Limited observation time and smaller number of treatment students. Since the last wave of data included in this analysis was from fall 2016, to ensure comparability of the outcomes between treatment conditions, this study limited the observation time to the first year of program enrollment, which is not long enough for the program to take effect. As a result, the analysis sample included relatively few students who could be considered treatment group members. Should additional years of data become available, the number of students in this group would grow.

3. History threat associated with the pre-post program comparison. The analysis is limited by the data available, which allows for a comparison between cohorts that enrolled in developmental math programs before and after the full implementation date. Student outcomes, however, may be influenced by other school events that occurred that are not reflected in the data, such as economic conditions resulting in differences in college-going rates and changes in admission policies.
4. Potentially insufficient control for group differences. The propensity score analysis adjusts for the preprogram differences based on the limited number of demographic and academic variables available in the data provided for this study. As a result, the analysis may not fully capture the pre-program differences between treatment and comparison group students such as pre-college experiences.
5. Limited outcomes for evaluation. Due to the limited reporting period, the analysis is constrained to outcomes attained within one year of enrollment, before many students could complete developmental math and a college-level math course, the two outcomes of greatest interest for this study. Finally, although the institutional research office provided data on students' performance in each required developmental math course and in later college-level math course, without information on the term in which the course was taken, the evaluation team is not able to evaluate whether a student completed the developmental math sequence within the first year.

## Summary

The quantitative analysis indicates that adopting an emporium model for the developmental math program did not have a significant impact on student GPAs or credit accumulation at the UM and UC during the first year of enrollment. In addition, the analysis indicates that students who enrolled after the implementation of the emporium model at UM were less likely to remain enrolled at the end of the first year than students who had enrolled before implementation. This was also true at MC: however, students enrolled at MC were not significantly less likely to remain enrolled after a year. As noted previously, these findings are based on data drawn from too short a time frame to comment definitively on the effectiveness of the emporium model for improving students' educational outcomes, and should be considered preliminary.

A more definitive analysis would include data on developmental math students enrolled in more recent terms, which would allow for an assessment of student outcomes within two years of enrollment—a more typical timeframe for program completion. Additionally, the inclusion of data fields detailing when students took their developmental and college math

courses would make it possible to evaluate their success in those programs within the same two-year timeframe.

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