Comparison of Three Delivery Approaches for Intermediate Mathematics at North Carolina Agricultural and Technical State University

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Abstract

The purpose of this study was to explore the impact three instructional delivery approaches for teaching intermediate mathematics (MATH 099) at North Carolina Agricultural and Technical State University (NC A&T) has on student success and retention. The three instructional delivery approaches were the: traditional model (lecture format); emporium model (lecture replaced by computer-based format); and the fully online model (internet format). The study was also designed to provide a general evaluation of the course as a necessary pathway to college completion. This evaluation compared only those full-time new freshmen students taking the Intermediate Math course for the first-time in the fall 2012 Semester. Data were collected to assess student success and retention.
Report

Introduction

This study is a comparative evaluation of the success rates (the students who passed the course) in the intermediate mathematics (MATH 099) course at North Carolina Agricultural and Technical State University (NC A&T) for the fall 2012 semester. The intermediate mathematics course is offered in the Center for Academic Excellence (CAE), a full service academic unit responsible for providing learning support to students. The MATH 099 course is the only developmental course offered by the university. The developmental intermediate mathematics course covers basic mathematics, introductory algebra and intermediate algebra, a review of high school work in one semester. It is a core base credit-bearing course that serves as a gateway to the general education college-level mathematics and science courses; however, the credit hours received for successfully completing the course do not count towards graduation.

Approximately one-third of the new freshmen students at NC A&T are required to enroll in the developmental intermediate Mathematics (MATH 099) course offered in CAE. These students are academically underprepared for college-level work. Improving students' success and progression through MATH 099 is one of the greatest challenges the University faces in the efforts to increase retention and graduation rates. One hurdle for degree-seeking students at NC A&T may be having to progress through developmental mathematics to successful degree completion. This makes MATH 099 an integral component of the university’s efforts to improve students’ success and progression towards graduation.

In North Carolina and across the country, more students are enrolling in the university today than ever. Many of them are underprepared for college-level work and are assigned to developmental courses; specifically, they enter college without the math skills necessary to succeed in college. The general consensus is that unsatisfactory student performance in college
mathematics courses is due to under-developed algebra skills (Roderick, 2009). These courses are offered to prepare students’ to pass required general education courses; yet, over the past decade, most of the four year schools in the University of North Carolina (UNC) system have been restrained in their use of remedial education. Differing definitions or remediation across the campuses makes it difficult to evaluate the effectiveness of remedial education across the campuses (Robinson, 2011).

North Carolina A&T State University Strategic Plan, Preeminence 2020, provides a strategic framework for its future growth and development. The plan provides clear guidance and direction for the upcoming decade. The plan allows the university to nimble as adjustments are made in response to emerging opportunities and the significant social, economic and global challenges Higher Education faces. North Carolina A&T along with the four-year schools that make up the University of North Carolina (UNC) system have been restrained in their use of remedial education. There is no evidence that the schools’ efforts to remediate students have been successful in the UNC system. With this challenge, the stakes are high for the MATH 099 course.

The MATH 099 course is not remedial but developmental in nature. Historically, the terms remedial and developmental education were used interchangeably. Many educators make the distinction between the two terms. The term remedial is used to describe the instruction that has or should have been provided in the past e.g. basic arithmetic. The term developmental is used to describe instruction that prepares students for specific college level courses e.g. thinking critically or studying effectively (Arendale, 2005). The National Association of Developmental Education (NADE) shifted the focus in the 80’s from using remedial to developmental as the preferred descriptor of all below college-level courses.
The developmental intermediate mathematics course in the CAE at NC A&T is designed to strengthen students' basic skills so they can successfully complete college-level courses. The math team takes a holistic approach to educating developmental students. Through the programs offered in the Center, students have access to a broad array of alternative services such as Supplemental Instruction (SI), tutoring, intrusive academic advising, academic alert intervention, and learning assistance services. Boylan (2009) argued that alternatives to developmental education should be offered as an essential part of any modern developmental program. As a result, we will find that there will no significant differences in instructional delivery.

Additionally, the math team subscribes to NADE’s motto of helping the underprepared student to prepare, the prepared student to advance, and the advanced student to excel. Our endeavor is to enable all students to achieve their maximum potential and enhance their chances for academic success at the university. We must prepare ourselves to meet changes mandated by the UNC system by increasing the projection to retain and graduate students enrolled in the developmental MATH 099 course at the university.

Background

The change in instructional delivery for intermediate mathematics was first initiated in 2007 in conjunction with the University-wide Retention Initiative. Mandatory tutorials were required of all students who did not score 85% or above on the first and subsequent math exams throughout the semester. The instructors began providing individual/group tutoring for the students as needed.

In the fall 2008 semester, the University Mathematics Department and CAE collaborated to revise the two curricula to connect and reviewed many products prior to making a change. Both departments selected textbooks from Pearson Publishing with different authors. The textbooks were supplemented with a student access kit for MyMathLab/MyMathLabsPlus, an
online teaching and learning environment to do out-of-class homework assignments to supplement the material taught in the lecture.

In fall 2010, Instructor-led SI and an alert intervention initiative were piloted in the developmental math course as a result of the A&T Wabash 2010 Study in Mathematics. The letter grade for MATH 099 students to progress to the subsequent mathematics course was approved for change by the faculty-senate from a letter grade “D” to “C”. This policy was put in place in an effort to increase the pass rate of developmental students in the subsequent college-level math courses. A minimal 25 sessions of mandatory tutorials and/or peer-/instructor-led SI was added for all students enrolled in the course.

Remedial education declined in 1991 in the UNC system; however, over the last few years it has grown. In 2011-2013, the budget priorities list asked for targeted funds of approximately $5 million dollars to improve graduation and retention rates (some of which was designated for remediation) at eight of the schools (Robinson, 2011). Although NC A&T was not named among the schools listed, the developmental math team was placed on alert. We began to look at other best practices for redesigning the developmental intermediate mathematics course that would accelerate students through the program.

The university Office of Distance Learning awarded funding to the CAE Instructional and Academic Support Programs Coordinator to design the online version of the development education course in intermediate mathematics. In fall 2011, the first online developmental class was implemented. In addition, pilots were done over the course of the academic year in two classes of the course each semester using the replacement model. The course met five days per week: three days were traditional lecture; and two days was replaced with either peer-led SI or as an in-class computer lab. The traditional sections continued to require 25 mandatory hours of
tutorials and/or peer-/instructor-led SI. During the summer sessions, the emporium model was piloted.

In 2012, CAE led the initiative to open the first math emporium at the university, for the developmental math course (MATH 099) and the subsequent college-level introductory algebra courses (MATH 101/102). Through providing an innovative and creative setting that supports experimentation, change and the development of new practice paradigms, any educational gaps in students’ backgrounds can be bridged to help students, specifically the underprepared students, make a smooth and successful transition into college-level work. This project connects with the university’s strategic goal of promoting excellence in teaching and learning as well as ensuring student success.

Pearson Publishing MyMathLab (MML) Developmental Mathematics, eCourse Series is the electronic version of the Squires and Wyrick textbook chosen for the intermediate mathematics course. This software product, MyLabsPlus, was coordinated with the textbook for the emporium and online classes. The product was also available as a stand-alone computer version supplement for students in the traditional classes. According to Carol Twigg from the National Center of Academic Transformation, course redesign must be done in all sections of a course to be effective (Twigg, 2011).

Method

This study explores three instructional delivery approaches for teaching the developmental intermediate mathematics (MATH 099) as it relates to student success and retention. The study was also designed to provide a general evaluation of the course as a necessary pathway to college completion, compare the delivery approach of three class formats, and learn from the experience. To this end, we compared student performance and persistence.
Participants

The sample consisted of students enrolled in the developmental MATH 099 course in the fall 2012 semester at NC A&T. North Carolina A&T State University is a land-grant research intensity four-year public university located in Greensboro, North Carolina, United States. It is the largest publicly funded historically black college/university (HBCU) in the state of North Carolina. The university was established before 1964 with the intention of serving the black community. As a public university, NC A&T offers a full spectrum of opportunities.

The MATH 099 course is required of students whose placement scores on the mathematical portion of: the Scholastic Assessment Test (SAT) is less than 440 or the American College Test (ACT) is below 16; or the University Mathematics department placement test score is below 15. The students were randomly enrolled in the course using Banner, the key information system used at the University. The system is programmed so that those students whose placement scores fall within the criteria range are allowed to register for any open section of the course; however, the math department chair or office of the registrar can override the placement prerequisite at the request of the faculty advisor, department chairperson, dean, or a parents request.

There were 20 sections of the MATH 099 course offered in the fall 2012 semester. The 20 sections participating in this study comprised of all full-time new freshman students who enrolled in the course for the first time. The average age of the student was 18 years old; the average SAT score was 400; and the average high school Grade Point Average (GPA) was 3.03. The total number of students enrolled in the MATH 099 from day one through the end of the semester of the course was 484: 384 in the 16 sections using the traditional model; 89 of the three sections using the emporium model; and one in the fully online model.
The fully online delivery approach will be excluded from the study as the one student enrolled under the specific criteria never participated in the online class. Research has shown that first-time new students who enroll in online courses are significantly more likely to fail or withdraw than those in traditional classes. Courses delivered solely online are inappropriate for struggling students who make up a significant portion of enrollment and who need close contact with the instructors to be successful (Rosenthal, 2013).

The MATH 099 instructional team for this study includes five Academic Counselors/Lecturers (Mathematics), one Mathematics Adjunct, two Graduate Teaching Assistants (GTAs), a SI leader/mentor, and two SI/Peer leaders. All instructors and the adjunct hold Masters degrees in Mathematics: three have Masters of Science in Mathematics Secondary Education; two have Masters of Science degrees in Applied Mathematics; and one has a Masters of Arts in Mathematics Education. The Academic Counselors/Lecturers have been employed in CAE to teach math for at least four years: one for 13 years; two for five years; and two for four years. Prior education experience includes teaching in secondary education, engineering, and teaching in higher education. Four of the Academic Counselors/Lecturers received their Masters degree from NC A&T. All are qualified to teach college-level mathematics and meet the Southern Association of Colleges and Schools (SACS) guidelines required of mathematics faculty; they have a minimum of 18 credit hours at the graduate-level.

The two GTAs are applied mathematics majors with extensive experience in tutoring. The SI Leaders have worked in CAE as SI leaders for three years. The SI leader/mentor is an Applied Mathematics and Economics major; and the SI leaders are both Mathematics, Secondary Education majors. All student assistants are nationally certified tutors. The Centers peer tutoring program is level-one certified by the College Reading and Learning Association (CRLA).
Design

There were 20 sections of MATH 099 offered in the fall 2012 semester: 17 traditional lecture formats, three Emporium formats, and one online format. Four academic counselor/mathematics lecturers and one adjunct taught the course. The sections of the course were distributed as follows: one lecturer taught three sections of the traditional and two Emporium sections; one lecturer taught two traditional, one emporium, and the online sections; two lecturers taught four traditional sections each; and an adjunct lecturer taught three traditional sections.

The standard requirement for each delivery approach includes: a Student Access Kit for MyLabsPlus (MLP), course pre/post tests, homework assignments, and 20 topic mastery quizzes. The delivery approaches are as follows:

- Traditional model (lecture format): Regularly scheduled in-class meetings. Lectures and textbooks supplemented with technology based out-of-class activities in MLP and mandatory 20 hours of academic support services through the tutorial/SI programs.

- Emporium model (lecture format replaced by in-class computer-based format): The emporium model replaces lectures with a learning resource center model, the Emporium Math Lab, featuring Pearson Publishing interactive software in MLP and on-demand personalized assistance from the instructor, Graduate Teacher Assistant, or undergraduate peer tutor.

- Fully online model (Internet Format): The fully online model eliminates all in-class meetings and moves all learning experiences online using Web-based, multimedia resources, commercial MLP interactive software, automatically evaluated assessments with guided feedback and alternative staffing models.
Class enrollment varied for each delivery approach. Maximum enrollment capacity was as follows: traditional model, 30 seats; emporium model, 36 seats; and fully online model; 25 seats.

The traditional sections met for three days per week for 50-minute sections in a traditional style classroom. The instructional team included an Academic Counselor/Lecturer and an SI/Peer leader; the ratio of students to instructional team was 15:1. The classrooms in the new Academic Classroom Building are designed for cooperative learning.

While the emporium sections met five days per week for three 50-minute sections that replaced the lecture time, one mandatory 50-minute in-class lab, and one mandatory 50-minute out-of-class lab during the open hours of operation schedule in the new Math Emporium Laboratory. The instructional team for this model included an Academic Counselor/Lecturer, GTA, and a SI/Peer leader; the in-class ratio of students to instructional team was 12:1.

Materials

The campus course management system for NC A&T fall 2012 was Blackboard (Bb) 9.1. This was where the instructors put the syllabus and homework assignments for students, hold online discussions asynchronously, an even hold synchronous online office hours.

The textbook publisher, Pearson Education, has a private-label Course Management System, CourseCompass (CC), which contains a rich array of resources the students and instructors utilized, MyLabsPlus (MLP). MyLabsPlus is an online multimedia textbook, tutorials, practice, homework, quizzes, and other educational resources. To facilitate the success of students in MATH 099, the on-campus Bb system served as a portal, or gateway, to the CC materials.

All students completed the semester pre-test which also served as the post-test/final exam at the end of the semester. The test came from pre-made questions randomly assigned by the computer to cover the entire course of topics. There were 32 problems on the test. The
traditional students completed the pencil-paper test in-class pre-test, no later than the third class
meeting of the semester, and the post-test during the final exam week of the course. The
emporium and online students completed a similar test on the computer; the problems were
randomly assigned; however, the problems were selected by the in-house administrator.

The traditional classes attended lecture three days per week. The lecture was designed to
cover the topics outlined on the schedule. Collaborative exercises and guided practices were
completed in-class. Homework was assigned in MLP. At the end of the topic, the students also
completed a pencil-paper test monthly on the topics covered in class. A mastery quiz was
assigned as out-of-class homework.

The students enrolled in the emporium classes took a pre-test at the beginning of each
mini-mod topic. If the student received a score 85 or better, the student could precede to the next
topic, after going over the material missed on the pre-test one-on-one with the instructor, GTA,
or SI leader. If the student did not receive a score of 85 or better, the following format was used
to complete the three tasks for each topic:

(1) The students watched the tutorial to learn the content through a three-part, flash
based tutorial created by the author of the eText. The students:

a. viewed step-by-step videos narrated by the author;

b. completed the interacted guided examples by clicking through each step of
the solution; and

c. concluded the tutorials with a study guide that offered a concise summary
of key definitions and procedures for the topic.

(2) The students were given four multiple-choice questions to answer to check for
conceptual understanding and ensure the student grasped the key idea. The
students could not move on to the homework assignment until they completed the concept check correctly.

(3) The student completed the 10 homework questions offered in MLP. The students could use “View an Example” and “Help Me Solve This” features for the first five questions. The remaining 3-5 questions in each assignment required the students to solve the problem on their own, without any learning aids. The students had to complete homework assignments with a score of 100 before moving to the post-test; they could repeat the assignment four times to obtain this score. Desired homework problems can be printed out and worked out on paper or the student can use the workbook for the course.

The students then had to complete the mini-mod post-test (equivalent to the mastery quiz for the students enrolled in the traditional course. The students had to pass the post-test with a score of 85 or above; they could repeat the post-test up to two attempts to move to the next mini-mod topic. The instructional team worked with the student one-on-one to ensure that the students understood the items missed on the test.

**Instrumentation**

The instruments used in the study consisted of: computer-based multiple-choice and fill-in the blank course pre-/post tests selected by the team of instructors; and randomly selected computer-based homework assignments and topic mastery/mini-mod quizzes through *MyLabsPlus* (MLP). The MLP eCourse offered the students a guided learning path through content that was organized into smaller, more manageable portions rather than by chapters and sections. These pre-made tutorials and assessments were referred to as mini-modules (mini-mod). Each mini-mod was a week’s worth of content allowing for frequent assessment. The course covered 20 mini-mods. A pacing guide was included with the syllabus.
The traditional format included four in-class exams which contained different topics, thus precluding direct exam-to-exam comparison. Nevertheless, since the classes covered the same topics and questions were drawn from the same test bank, a direct comparison of the average of the exam scores calculated in the final course grade was possible.

Data Collection

Data were collected from the instructors on an on-going basis throughout the semester. The instructional support team compiles grades twice before semester’s mid-term as an early alert to academic counselors and faculty advisors of students requiring extra help maneuver through the MATH 099 course. Grades are assigned in MLP immediately so that students receive instant feedback. All assignments done in MLP were scored and recorded as students progressed through the assignments. The grades are exported to Bb so that the student can access their grades. Banner student information system and institutional research information was used to compare with the data collected from the instructional team.

Data collection included pre-/post-test scores and the per cent increase or decrease between the original and final test scores; pencil-paper test grades were calculated in the end of term grade; homework grades and mini-mod quizzes were used to calculate the final grades. The final grade was determined by a compilation of homework, mastery/mini-mod quizzes, and the post-test grade was used as the final exam grade.

All students were given the same pre-/post-test. The pre-test was given the first week of the term and the same test was given as a post-test at the end of the semester. The mastery/mini-mod quizzes came from a pool of random questions created by the author of the eText and were provided using a pacing guide throughout the semester. For the traditional class, four pencil-paper tests were given every three-to-four weeks throughout the semester.
Data Analysis

The analysis of our data was done using the following tests: comparison of means and one-way Analysis of Variance (ANOVA), Tukey’s HSD test, Chi-squared test, and the T-test. These tests were performed to determine which groups, traditional or emporium delivery approach, differ. It also tells if the samples of data using the two delivery approaches differ. The tests revealed to us which groups among the samples have a significant difference.

Student performance was evaluated by comparing the pre-/post-test averages, mastery/mini-mod quiz averages, and final grade distribution scores between the traditional and emporium delivery approaches. (The fully online delivery approach will be excluded from the study as the one first-time new freshman student enrolled in the course never participated in the online class). The SAT scores of those new freshmen students in relation to the final grade in the course as well as the students’ high school Grade Point Average (GPA) evaluated.

Findings

The goal was to determine if there were significant differences in student performance between the two delivery approaches used to teach the developmental MATH 099 at NC A&T during the fall 2012 semester. Although five different instructors taught the three different delivery approaches, use of the same text, homework assignments, mastery/mini-mod quizzes and paper and pencil tests and format allow for direct comparison. It should be noted that the instructors also taught the course for a number of years and had a long history of coordinating the content, topic sequence and projects in the different sections of the course.

A direct comparison of the pre- and post-test scores for the two delivery approaches in the traditional and emporium class was undertaken. The pre-test was administered during the first week of the course and the same test was administered as the post-test at the end of the semester. The same pre-test was used in both the traditional and emporium classes. However, the settings
were different: the traditional class took a pencil-paper test in a traditional style classroom. The emporium students took their test in the emporium lab during the scheduled class time. As is evidence by examining Table 1, there were significant differences in the pre-test average between the two delivery approaches. This could be related to the student’s inexperience and being unfamiliar with completing online computer based assessments at the beginning of the semester and becoming more techno savvy towards the end of the semester.

Table 1: Pre-/Post-test Scores

<table>
<thead>
<tr>
<th>MODEL TYPE</th>
<th>Pre-Test Average</th>
<th>Post Test Average</th>
<th>Pre-Post % Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRADITIONAL</td>
<td>61</td>
<td>74</td>
<td>21%</td>
</tr>
<tr>
<td>EMPORIUM</td>
<td>28</td>
<td>83</td>
<td>199%</td>
</tr>
</tbody>
</table>

The significant difference in the pre-test average between the two delivery approaches could be related to the student’s inexperience and being unfamiliar with completing online computer based assessments.

Statistical analysis using t-tests indicates that there is no significant difference between the mean test scores.

Chart 1: T-test for Pre-/Post-test Scores

<table>
<thead>
<tr>
<th>T-Test 1-Sample</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Mean</td>
<td>55.4</td>
<td>61.5575</td>
<td>24.20742087</td>
</tr>
<tr>
<td>Confidence Level</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>N</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Average</td>
<td>61.5575</td>
<td>74</td>
<td>24.20742087</td>
</tr>
<tr>
<td>St.dev</td>
<td>24.20742087</td>
<td>24.20742087</td>
<td>0.783</td>
</tr>
<tr>
<td>SE Mean</td>
<td>12.10371043</td>
<td>12.10371043</td>
<td>0.783</td>
</tr>
<tr>
<td>T</td>
<td>-0.509</td>
<td>-0.509</td>
<td>-0.509</td>
</tr>
<tr>
<td>TINV</td>
<td>2.353363435</td>
<td>2.353363435</td>
<td>2.353363435</td>
</tr>
<tr>
<td>p - One sided</td>
<td>0.32299781</td>
<td>0.32299781</td>
<td>0.32299781</td>
</tr>
</tbody>
</table>

Accept Null Hypothesis because p > 0.05 (Means are the same)
Comparison of the average mastery/mini-mod quizzes scores for the two delivery approaches yielded that there is little difference between the average scores. The mastery quizzes and mini-mod quizzes were the same quizzes with different titles: mastery was used for the traditional sections, and mini-mod quizzes for the emporium sections. There were 20 quizzes given based on the number of topics covered. Again, the online model was dropped from comparison for the reason stated above. Examination of the data from table 2 clearly shows how close the results were, T-tests between the sets of scores indicate no significant difference between the average scores.

Table 2: Mastery/Mini-mod Quizzes Score Average

<table>
<thead>
<tr>
<th>Model Type</th>
<th>Mastery Quiz Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>89%</td>
</tr>
<tr>
<td>Emporium</td>
<td>88%</td>
</tr>
</tbody>
</table>

The final grade distribution and pass rate for the two delivery approaches were compared and yielded similar results as to those of the mastery/mini-mod quizzes average above. Final grades included homework assignments, mastery/mini-mod quizzes, and participation (attendance). Examination of the data in Table 3 clearly showed how close the results were. Of the 483 first-time new freshmen students enrolled in the MATH 099 course, 448 completed the course successfully: 364 students in the traditional model, and 84 in the emporium model. (Prior
to fall 2012, only those students who passed the course with a grade “C” or better were only allowed to progress to the next subsequent math course. This policy changed effective fall 2012.

Table 3: Final Grade Distribution and Percent Pass Rate

<table>
<thead>
<tr>
<th>DISTRIBUTION PATTERN</th>
<th>TOTAL #</th>
<th>TOTAL #</th>
<th>GRAND</th>
<th>PERCENT PASSING</th>
<th>PERCENT PASSING</th>
<th>TOTAL PERCENT PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL/ GRADE</td>
<td></td>
<td>A-D</td>
<td>F</td>
<td>A-D</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>TRADITIONAL</td>
<td>364</td>
<td>30</td>
<td>394</td>
<td>92%</td>
<td>8%</td>
<td>100%</td>
</tr>
<tr>
<td>EMPORIUM</td>
<td>84</td>
<td>5</td>
<td>89</td>
<td>94%</td>
<td>6%</td>
<td>100%</td>
</tr>
<tr>
<td>OVERALL</td>
<td>448</td>
<td>35</td>
<td>483</td>
<td>93%</td>
<td>7%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Charts 1 and 2, also, show how close the results are. T-tests between the sets of percent pass rate scores also indicate no significant difference between the final grades.

Chart 2: Percent Pass Rate for the Traditional Delivery Approach

![PASS RATE TRADITIONAL MODEL Fall 2012](chart2)

Chart 3: Percent Pass Rate for the Emporium Delivery Approach

![PASS RATE EMPORIUM MODEL Fall 2012](chart3)
Although final grade distribution results are just one out of several criteria normally used in evaluating student performance, in this situation they serve as a readily available measure. It appears from the data collected, that there was no significant difference in student performance, regardless of the delivery approach. This is an encouraging result, and bodes well for the future of the emporium delivery model. Table 4 and charts 3 and 4 show how close the results are. T-tests between the sets of scores also indicate no significant difference between the final grade score.

Table 4: Final Grade Percentage Distribution for the Two Delivery Approaches

<table>
<thead>
<tr>
<th>GRADE %</th>
<th>EMPORIUM</th>
<th>TRADITIONAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>48%</td>
<td>21%</td>
</tr>
<tr>
<td>B</td>
<td>29%</td>
<td>36%</td>
</tr>
<tr>
<td>C</td>
<td>13%</td>
<td>28%</td>
</tr>
<tr>
<td>D</td>
<td>3%</td>
<td>8%</td>
</tr>
<tr>
<td>F</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Chart 4: Final Grade Percent Distribution for the Traditional Delivery Approach
There appears to be a significant difference of the number of students who received letter grades "A" and "B" with the emporium model in comparison to the traditional model; however, there was not a significant difference between the overall percent pass rate scores for the two delivery approaches.

Since placement into MATH 099 is based on the placement scores of new first time freshmen, a direct comparison of the students final course grade and the SAT score. The average of the mathematical portion of the SAT for first-time new freshmen students enrolled in the course is as follows: 406 for traditional class; and 390 for the emporium class. (The online class was not included in the statistical analysis as the only student never attended a session of the online class). There is no significant difference in the score.

Table 5: Mathematical score on SAT Compared to Final Course Grade

<table>
<thead>
<tr>
<th>MODEL TYPE</th>
<th>SECTIONS</th>
<th>TOTAL ENROLLED</th>
<th>FINAL GRADE &quot;A&quot;</th>
<th>FINAL GRADE &quot;B&quot;</th>
<th>FINAL GRADE &quot;C&quot;</th>
<th>FINAL GRADE &quot;D&quot;</th>
<th>FINAL GRADE &quot;F&quot;</th>
<th>AVERAGE MATHEMATICS SAT SCORE</th>
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</thead>
<tbody>
<tr>
<td>TRADITIONAL</td>
<td>16</td>
<td>394</td>
<td>424</td>
<td>410</td>
<td>397</td>
<td>408</td>
<td>389</td>
<td>406</td>
</tr>
<tr>
<td>EMPORIUM</td>
<td>3</td>
<td>89</td>
<td>417</td>
<td>399</td>
<td>378</td>
<td>377</td>
<td>378</td>
<td>390</td>
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<tr>
<td>OVERALL</td>
<td>20</td>
<td>484</td>
<td>421</td>
<td>405</td>
<td>388</td>
<td>393</td>
<td>392</td>
<td>399</td>
</tr>
</tbody>
</table>
Assessment of the impact of the final grade using the SAT score for the students enrolled in MATH 099 using the two delivery approaches: Thus, we accept the null hypothesis: There are no relationships between students in the traditional and emporium delivery approaches their SAT scores.

Table 6: One-way ANOVA Using the Average SAT for each Letter Grade

<table>
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<tr>
<th>Groups</th>
<th>Count</th>
<th>Sum</th>
<th>Average</th>
<th>Variance</th>
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</thead>
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<td>1949</td>
<td>389.8</td>
<td>316.7</td>
</tr>
<tr>
<td>Traditional</td>
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<td>2023</td>
<td>404.6</td>
<td>224.8</td>
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<table>
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<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
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</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>547.6</td>
<td>1</td>
<td>547.6</td>
<td>2.02253</td>
<td>0.192776</td>
<td>5.317655</td>
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<tr>
<td>Within Groups</td>
<td>2166</td>
<td>8</td>
<td>270.75</td>
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<td></td>
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</tr>
<tr>
<td>Total</td>
<td>2713.6</td>
<td>9</td>
<td></td>
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</table>

* Null Hypothesis: There are no relationships between students in Math Emporium and Traditional SAT average (Accept).

There was no difference between the SAT and the final grade for the course. When we looked at the mean SAT scores, our findings indicate. Finally, we ran Tukey’s test to see if the average SAT for each grouping of letter grades is different.

From the output we see that the p value = 0.192776 for the delivery approach indicating that the SAT scores have no significant effect on the response. This desirable since it is expected the students can discern correctly the two types of delivery approaches. In table 7, we see that the ANOVA p-value for the type of delivery approach is highly significant, indicating the difference between the two approaches. So from this point on, we can use the Tukey test to see where the differences lie.

Thus, the results of Tukey’s Test follow:
Table 7: Tukey’s Test to compare the Means

*Tukey multiple comparisons of means*

95% family-wise confidence level

<table>
<thead>
<tr>
<th>DIFFERENCE</th>
<th>LOWER</th>
<th>UPPER</th>
<th>P. ADJ.</th>
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</thead>
<tbody>
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<td>33.5871</td>
<td>0.70639</td>
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<tr>
<td>C-A</td>
<td>-33.0</td>
<td>16.5871</td>
<td>0.190799</td>
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<td>D-A</td>
<td>-28.0</td>
<td>21.5871</td>
<td>0.290499</td>
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<tr>
<td>F-A</td>
<td>-39.5</td>
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<td>0.110902</td>
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<td>C-B</td>
<td>-17.0</td>
<td>32.5871</td>
<td>0.665452</td>
</tr>
<tr>
<td>D-B</td>
<td>-12.0</td>
<td>37.5871</td>
<td>0.857985</td>
</tr>
<tr>
<td>F-B</td>
<td>-23.5</td>
<td>26.0871</td>
<td>0.418756</td>
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<td>D-C</td>
<td>5.0</td>
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<td>F-C</td>
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<td>F-D</td>
<td>-11.5</td>
<td>38.0871</td>
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</table>

This output indicates that the differences B-A, C-A, D-A, F-A, C-B, D-B, F-B, D-C, F-C, and F-D are not significant because the confidence interval contains zero (0). Tukey’s test supports the ANOVA findings. Thus, we Accept the *Null Hypothesis: There are no relationships between students mean SAT score and the delivery approaches.*

Comparing the high school mean GPA to the final grade of the two delivery approaches indicates that the high school GPA does play a huge factor in how well students perform in the traditional and emporium approach. There is an average high school GPA drop of 0.13 points per letter grade for the traditional and emporium delivery approaches.
The chart below shows the statistical analysis of the mean high GPA for first-time new freshman who are enrolled in the traditional and emporium models.

In a 2008 study by the nonprofit Strong American Schools, they found that nearly four out of five remedial students has a high GPA of 3.0 or higher. Robinson (2011) related this to poor standards in high schools. She indicated that high schools failed to prepare these students
for college-level work and have misled them about their abilities to succeed academically (Robinson, 2011).

The search for strategies to increase student success is measured in persistence and graduation rates. Graduation rates, along with retention rates, are ostensibly as indicators of academic quality and student success. Retention rates measure the percentage of freshmen that enroll the next academic year as sophomores. In addition to retention, persistence helps to describe the process related to the student goal. remain in school at a rate similar to those enrolled in college-level courses.

The primary intended outcome of NC A&T CAE developmental intermediate mathematics course (MATH 099) is to position students to be successful on their first attempt in a college-level math course. The persistence rate for the first-time new freshman students’ enrolled in a subsequent or required math course in the spring 2013 semester is 100%: 364 traditional students, 89 emporium students, and one online student. Ninety-four percent of the first time new freshmen students’ enrolled the traditional course moved to the next subsequent or required course and six percent of those students’ repeated MATH 099; and 96% of the first-time new freshmen students enrolled in the emporium model moved to the subsequent or required math course and four percent of the students’ in the emporium sections repeated the MATH 099 course. Data on persistence rates over the semester revealed that students in the developmental math course all enrolled in a math course for the spring 2013 semester.

The subsequent math courses for students enrolled in MATH 099 at NC A&T for the fall 2012 semester are the following college-level math courses: Fundamentals of Algebra and Trigonometry I (MATH 101), Fundamentals of Algebra and Trigonometry I (MATH 103) for Science, Technology, Engineering and Mathematics (STEM) majors, or College Algebra and
Trigonometry (MATH 111). There were students who were advised to take a higher math course under the advisement of their academic advisor.

There were 384 students enrolled in the traditional sections of MATH 099; 336 of these students took the subsequent math course; 283 of these students passed the subsequent math course; thus, the students who persisted from MATH 099 had an 84% pass rate in the subsequent math course at the end of the spring 2013 semester. There were 89 students enrolled in the emporium section of MATH 099; 75 of these students took the subsequent math course; 63 of these students passed the subsequent math course; thus, the students who persisted from MATH 099 had an 84% pass rate in the subsequent math course at the end of the spring 2013 semester.

Table 8: New Freshmen Traditional Model Subsequent Math Course Grade Distribution Spring 2013

<table>
<thead>
<tr>
<th>NF - Traditional MATH 099</th>
<th>Subsequent Final Grade Spring 2013</th>
<th>Total NF Enrolled</th>
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<tr>
<td>MATH 101 Sections</td>
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<td>5 9 6 3 2</td>
<td>25</td>
</tr>
<tr>
<td>003</td>
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<td>004</td>
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<td>005</td>
<td>4 7 5 2 4</td>
<td>22</td>
</tr>
<tr>
<td>006</td>
<td>1 2 9 4 5</td>
<td>21</td>
</tr>
<tr>
<td>007</td>
<td>2 8 3 5 3</td>
<td>21</td>
</tr>
<tr>
<td>008</td>
<td>5 8 6 3 4</td>
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<td>009</td>
<td>4 6 4 0 4</td>
<td>18</td>
</tr>
<tr>
<td>010</td>
<td>3 7 10 0 3</td>
<td>23</td>
</tr>
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<td>011</td>
<td>2 3 9 4 4</td>
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<tr>
<td>012</td>
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<td>17</td>
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<td>015</td>
<td>8 3 6 3 1</td>
<td>21</td>
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<tr>
<td>016</td>
<td>4 8 8 4 8</td>
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<td>018</td>
<td>0 4 6 4 2</td>
<td>16</td>
</tr>
<tr>
<td>021</td>
<td>10 4 6 0 0</td>
<td>20</td>
</tr>
<tr>
<td>Total Grade Distribution</td>
<td>58 97 88 40 53</td>
<td>336</td>
</tr>
</tbody>
</table>

24
Table 9: New Freshmen Emporium Model Subsequent Math Course Grade Distribution Spring 2013

<table>
<thead>
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<th>NF - Emporium MATH 099</th>
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<th>Total NF Enrolled</th>
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</thead>
<tbody>
<tr>
<td>MATH 101 Sections</td>
<td>A  B  C  D  F</td>
<td></td>
</tr>
<tr>
<td>001</td>
<td>3  8 10  7  4</td>
<td>32</td>
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<tr>
<td>013</td>
<td>4  5  6  3  3</td>
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</tr>
<tr>
<td>014</td>
<td>4  2  8  3  5</td>
<td>22</td>
</tr>
<tr>
<td>Total Grade Distribution</td>
<td>11 15 24 13 12</td>
<td>75</td>
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As with any study, there are situational and methodological limitations to be considered. Methodologically, the emporium model was a pilot study. Other limitations that should be considered are as follows:

- The SAT and ACT math score on the placement tests is the main criteria used to place students in the most appropriate Math class at NC A&T. These tests demonstrate the students have the minimum skills proficient to be admitted to the university. If a student believes they qualify for a mathematics course above the level they will be placed, they can request to take the University Mathematics Department placement test for Algebra and Pre-Calculus. Many colleges out west use the ACT only as placement. According to Princeton Review, the mathematics portion of the ACT tests more advanced concepts. Students who take the University Mathematics Department placement test are rarely successful. This infers that there is no significant difference between the students’ score low on the SAT/ACT and those who take the University math department placement test; the department test should be not be used in placing students into a math course. The test score indicates the students’ have a basic knowledge of a number of topics in mathematics, but the test does not assess their ability to do college level math or their readiness for introductory college courses.
• Although this course is required of students whose placement scores on the mathematical portion of: the Scholastic Assessment Test (SAT) is less than 440 or the American College Test (ACT) is below 16; or the University Mathematics department test score is below 15, there is no guarantee that the students who are declared in major are enrolled in the course. Those students’ placed in a major are advised by faculty in the department who have the autonomy to make the administrative decision for the student to enroll in the math course indicated by the departmental curriculum guide. The underlying assumption was that students were randomly distributed across course sections. Although students selected a course primarily based on time and place convenience, there may be some underlying fundamental difference among the students i.e. a conflict with another course in a specific major, conflict with practice schedule for band and athletics, or a work schedule.

• Each of the 20 sections used a common text book, test bank, and similar schedule assignments. Four different instructors and a new adjunct taught the course. Obviously, each instructor would place different topics and conduct the class in a slightly different manner. However, the instructors’ previous experience in covering concurrent sections of this course tended to minimize the differences in instructional approaches, but does not totally eliminate them. Therefore, it is possible that this could have had some impact on the results of the study.

• Since the emporium delivery approach was being offered for the first time, anomalies were discovered and subsequent course fine-tuning occurred as the academic semester unfolded. The instructors, with the exception of the adjunct, for these sections of the MATH 099 course are veterans. They were prepared for any cloud mishaps in the
empirion lab, glitches in the system and software, or errors with the e-text. We feel that these changes had a minimal impact on the results of this study.

**Conclusion and Recommendation**

As documented, this was a learning experience. As detailed previously, student performance was remarkably consistent from one section to another. Whether this can be attributed to instructional performance is debatable. From our instructional perspective, this means that the emporion sections can be offered with little concern over how well students will do in comparison with the courses taught traditionally. However, there was a marked improvement of how well students did on the pre-/post-test in the emporion sections.

The expected projected outcome was that the potential impact of the emporion delivery approach would warrant a complete redesign of the entire MATH 099 course using the emporion model. The Math Emporium model has consistently produced significant gains in student learning (Twiggs, 2011). Some of the key quality improvement strategies of the emporion model include: number of class meeting; emphasis placed on mastery learning; flexible learning pace; the use of technology; and a flexible learning-pace. The Emporium model enables the student to develop better learning and time management skills, set their goals and complete them, and become self-sufficient college students while mastering the mathematical content. As educators, Boylan indicates that, we cannot continue to think one size fits every student (2001). Thus, we will also need to offer traditional style classes with alternatives e.g. SI, tutoring, early alert, intrusive academic advising, and academic support programs.

The recommendation of two key designs was submitted to the Vice Chancellor of Academic Affairs to move forward with a total course redesign for intermediate mathematics course (MATH 099). The recommendation was as follows: recommendations on how to redesign the developmental course which will offer an accelerated version of MATH 099 for five
weeks and MATH 101 for 11 weeks of each semester. The course will have five mandatory class meetings. Although there was no significant difference in the delivery approaches, research has shown that students who take developmental courses do better if the class meets every day of the business week. Although the classes will be in-class computer-based, students must be strongly encouraged to work independently out-side of class on homework assignments and keep abreast of the pacing guide. The recommendations were as follows:

(1) Redesign the entire MATH 099 course as a MATH 101 Emporium course

   a. The course will have five (5) mandatory class meetings in the Emporium lab:
      i. three 50-minute emporium in-class sessions;
      ii. one 50-minute in-class lab session in; and
      iii. one 50-minute mandatory out-of-class open lab session.

(2) Redesign the entire MATH 099 course as a MATH 101 Hybrid course (a blend of computer-based online in-class Emporium learning with face-to-face interaction).

   a. The course will have five (5) mandatory class meetings in the Emporium lab:
      i. three 50-minute in-class online emporium class sessions; and
      ii. two 50-minute traditional face-to-face sessions.

Some of the key elements of this redesign plan should include:

- Accelerated MATH 099 will be customized for each student based on skill level;
- Learning environment will allow students and instructors to focus on skills that students lack, to study only topics which they are unprepared, and receive assistance only in areas where students have deficiencies;
- Software change for the MATH 099---must incorporate pre-test that blends with course material and remove skills overlap to streamline the curriculum;
- Allow students to start anywhere in the course sequence based on their learning needs and progress through the content modules at their own pace; spending the amount of time needed to master the module content, proceeding at a faster pace if possible or at a slower pace if necessary;
- Permit students to earn variable credit based on whether they complete one or both courses during a term.

Both recommendations include redesigning the course utilizing the emporium delivery approach as a stepping stone for improving developmental education students’ progress through MATH 099 and into college-level Mathematics (MATH 101/103/111). By shortening the timing and content, students can progress through the course at an accelerated rate. The emporium approach enables developmental students to remain on the pathway of reaching their college goals. Research has shown that the more actively engaged students are with faculty and peers at an institution the more likely they are to learn at higher levels (Braxton, Hirschy, and McClelland, 2004). Based on the findings of the pilot, the Vice Provost agrees with the course redesign.

The students’ success in intermediate mathematics provides a foundation for students moving forward into college-level courses. Students who are underprepared for college level math vary in learning styles, course commitment, and overall adjustment to the academic setting experienced on four-year college campuses. Developmental education has positive effects on underprepared students’ persistence, grade point average, and the average grade in first college-level courses (Boylan and Bonham, 1992; Boylan and Saxon, 1998; Gerlaugh, Thompson, Boylan, and Davis, 2007). The findings of this study show that the math emporium model provided equal if not better learning opportunities as those provided in traditional lecture-based formats. The results of this pilot study suggest the need for a broader emphasis on course redesign to reduce the number of remedial courses offered by the university and increase student
performance in subsequent courses that rely on a student's knowledge of basic math and algebra skills. We believe that enhancements in these areas contribute to the overall success of students and strengthen the likelihood of improving overall retention and graduation rates among this population of students.
References


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ADMINISTRATOR:
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Provost Academic Affairs – EPA Non-teaching
Center for Academic Excellence, All Academic Schools and Colleges
North Carolina A&T State University
Intermediate Mathematics (MATH 099)
SCHEDULE OF COURSES

Fall 2012
August 15 – December 7

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</table>

TOTAL  20  561

Please NOTE:
*Sections 001, 013, 015 are Math Emporium Model pilot classes
*Section 05A is an Online Model class (Usually restricted for non-traditional and out-of-state students)
*Sections 011, 017,018 were taught by the adjunct
*ALL Other sections are Traditional Model lecture classes linked with SI
North Carolina Agricultural and Technical State University
Center for Academic Excellence
Instructional and Academic Support Programs
Intermediate Mathematics (MATH 099)

SUMMARY OF GRADE DISTRIBUTION OF ALL ENROLLED
FALL 2012

<table>
<thead>
<tr>
<th>MODEL TYPE</th>
<th>SECTIONS</th>
<th>TOTAL ENROLLED</th>
<th>TOTAL GRADE &quot;A&quot;</th>
<th>TOTAL GRADE &quot;B&quot;</th>
<th>TOTAL GRADE &quot;C&quot;</th>
<th>TOTAL GRADE &quot;D&quot;</th>
<th>TOTAL GRADE &quot;E&quot;</th>
<th>TOTAL GRADE &quot;W&quot;</th>
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<tbody>
<tr>
<td>TRADITIONAL</td>
<td>16</td>
<td>470</td>
<td>92</td>
<td>155</td>
<td>131</td>
<td>38</td>
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<tr>
<td>PILOTS</td>
<td>4</td>
<td>114</td>
<td>49</td>
<td>34</td>
<td>12</td>
<td>3</td>
<td>8</td>
<td>5</td>
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<td>OVERALL</td>
<td>20</td>
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<td>141</td>
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<tr>
<td>MODEL/GRADE</td>
<td>TOTAL #</td>
<td>POPULATION</td>
<td>% PASS RATE</td>
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<td>% PASS RATE</td>
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<table>
<thead>
<tr>
<th>GRADE %</th>
<th>TRADITIONAL</th>
<th>PILOTS</th>
<th>OVERALL</th>
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<tr>
<td>A</td>
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<td>17%</td>
<td>24%</td>
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<tr>
<td>B</td>
<td>22%</td>
<td>25%</td>
<td>32%</td>
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<tr>
<td>C</td>
<td>30%</td>
<td>19%</td>
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<tr>
<td>D</td>
<td>7%</td>
<td>3%</td>
<td>7%</td>
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<tr>
<td>F</td>
<td>19%</td>
<td>22%</td>
<td>8%</td>
</tr>
<tr>
<td>W</td>
<td>9%</td>
<td>8%</td>
<td>3%</td>
</tr>
<tr>
<td>I</td>
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<td>6%</td>
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</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
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COURSE MODELS: Traditional vs. Pilots
(Replacement Models and Online)
* Traditional - class meets 3 days/week face-to-face lecture with outside MyMathLab Homework/Mastery Quizzes
* Pilot - Emporium: Class meets 5 days/week; 3 in-class lab, 1 mandatory scheduled lab, and 1 mandatory open-lab session
* Pilot - Fully Online: Online only using Squires and Wyrick eCourse Series
<table>
<thead>
<tr>
<th>WEEK</th>
<th>DATES</th>
<th>MODULE</th>
<th>ACTIVITIES</th>
<th>ASSESSMENT</th>
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<tbody>
<tr>
<td>1</td>
<td>08/15-08/18</td>
<td><strong>Introduction and Mini-Mod 0</strong> Orientation</td>
<td>Introduction to the Course Course Geography/Organization Online Orientation</td>
<td>Student Info Sht Orientation Quiz PRE-TEST</td>
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<tr>
<td>2</td>
<td>08/19-08/25</td>
<td><strong>Mini-Mod 1</strong> Whole Numbers</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 1 Quiz</td>
</tr>
<tr>
<td>3</td>
<td>08/26-09/01</td>
<td><strong>Mini-Mod 2</strong> Factors and Fractions</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 2 Quiz</td>
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<tr>
<td>4</td>
<td>09/02-09/08</td>
<td><strong>Mini-Mod 3</strong> LCM and Fractions</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 3 Quiz</td>
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<tr>
<td>5</td>
<td>09/09-09/15</td>
<td><strong>Mini-Mod 4</strong> Mixed Numbers</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 4 Quiz</td>
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<td>6</td>
<td>09/16-09/22</td>
<td><strong>Mini-Mod 5</strong> Operations with Decimals</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 5 Quiz</td>
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<td>7</td>
<td>09/22-09/29</td>
<td><strong>Mini-Mod 6</strong> Rates, Ratios, &amp; Percents <strong>Mini-Mod 7</strong> U.S./Metric Measurement</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 6 Quiz Mini-Mod 7 Quiz</td>
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<td>8</td>
<td>09/30-10/06</td>
<td><strong>Mini-Mod 10</strong> Statistics</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 10 Quiz</td>
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<tr>
<td>9</td>
<td>10/07-10/13</td>
<td><strong>Mini-Mod 11</strong> Real Numbers and Variables</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 11 Quiz</td>
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<td>10</td>
<td>10/14-10/20</td>
<td><strong>Mini-Mod 12</strong> Add/Subtracting Real Nos. <strong>Mini-Mod 13</strong> Multiply/Dividing Real Nos.</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 12 Quiz Mini-Mod 13 Quiz</td>
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<tr>
<td>11</td>
<td>10/21-10/27</td>
<td><strong>Mini-Mod 14</strong> Variables and Expressions</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 14 Quiz</td>
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<tr>
<td>12</td>
<td>10/28-11/03</td>
<td><strong>Mini-Mod 15</strong> – Part I Intro - Solving Linear Eqns. <strong>Mini-Mod 16</strong> – Part II Solv Lin Eqns./Inequalities</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 15 Quiz Mini-Mod 16 Quiz</td>
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<td>13</td>
<td>11/04-11/10</td>
<td><strong>Mini-Mod 21</strong> Intro to Polynom/Exp. Rules <strong>Mini-Mod 22</strong> Multiplying Polynomials</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 21 Quiz Mini-Mod 22 Quiz</td>
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<tr>
<td>14</td>
<td>11/11-11/17</td>
<td><strong>Mini-Mod 23</strong> Dividing Polyn/Exp Rules <strong>Mini-Mod 24</strong> Factoring Polynomials</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 23 Quiz Mini-Mod 24 Quiz</td>
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<tr>
<td>15</td>
<td>11/18-11/24</td>
<td><strong>Mini-Mod 26</strong> Intro Rational Expressions <strong>Mini-Mod 27</strong> Add/Subtracting Rat. Exp.</td>
<td>Watch Tutorial/PowerPoint Check Concept Understanding Study Guide</td>
<td>Homework Mini-Mod 26 Quiz Mini-Mod 27 Quiz</td>
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<tr>
<td>16</td>
<td>11/25-12/01</td>
<td><strong>End-of-Term Review</strong> (Mini- Mods 1-27)</td>
<td>Review Study Guide</td>
<td>Practice Test</td>
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<tr>
<td>17</td>
<td>12/02-12/07</td>
<td><strong>Comprehensive Exam</strong></td>
<td></td>
<td>Post-Test</td>
</tr>
</tbody>
</table>
Sample Pre/Post-test

1. Write a word name for the number.
   2580
   Choose the correct answer below.
   ○ Two thousand, five hundred eighty
   ○ Two hundred fifty-eight thousand
   ○ Two hundred fifty-eight
   ○ Two thousand, fifty-eight

2. Which property justifies the statement below?
   $3 \cdot 6 = 6 \cdot 3$
   Choose the correct property below.
   ○ A. Distributive Property of Multiplication over Addition
   ○ B. Commutative Property of Multiplication
   ○ C. Associative Property of Multiplication

3. Write the following expression using exponents.
   $9 \times 9 \times 9 \times 9 \times 9$
   $9 \times 9 \times 9 \times 9 = \square$

4. List all the factors of 12.
   The factors of 12 are [ ].
   (Use a comma to separate answers as needed.)

5. Simplify, if possible.
   \[
   \frac{0}{23}
   \]
   Select the correct choice below and, if necessary, fill in the answer box within your choice.
   ○ A. \[ \frac{0}{23} \]
   ○ B. The fraction is undefined.
1. Write a word name for the number.

2580
Choose the correct answer below.

- Two thousand, five hundred eighty
- Two hundred fifty-eight thousand
- Two hundred fifty-eight
- Two thousand, fifty-eight

2. Which property justifies the statement below?

3 \cdot 6 = 6 \cdot 3
Choose the correct property below.

- A. Distributive Property of Multiplication over Addition
- B. Commutative Property of Multiplication
- C. Associative Property of Multiplication

3. Write the following expression using exponents.

9 \times 9 \times 9 \times 9 \times 9
9 \times 9 \times 9 \times 9 \times 9 = \boxed{\phantom{0}}

4. List all the factors of 12.
The factors of 12 are \boxed{\phantom{0}}.
(Use a comma to separate answers as needed.)

5. Simplify, if possible.

\frac{0}{23}
Select the correct choice below and, if necessary, fill in the answer box within your choice.

- A. \frac{0}{23} = \boxed{\phantom{0}}
- B. The fraction is undefined.
6. Write the given fraction in simplest form.

\[
\frac{81}{108} = \square
\]

7. Multiply. Write the answer in simplest form.

\[
\frac{14}{51} \cdot \frac{3}{4} = \square
\]
(Type a whole number or a simplified fraction.)

8. (a) List the first five multiples of 4 and the first five multiples of 10.

(b) Which of these multiples are common to both lists?

(a) List the first five multiples of 4.

\[\square\]
(Use a comma to separate answers as needed.)

List the first five multiples of 10.

\[\square\]
(Use a comma to separate answers as needed.)

(b) Which of these multiple(s) are common to both lists?

\[\square\]
(Use a comma to separate answers as needed.)

9. Find the least common multiple (LCM) of 98 and 56.

The LCM of 98 and 56 is \[\square\].

10. Find the least common denominator (LCD) of the fractions.

\[
\frac{1}{10}, \frac{1}{3}
\]

The LCD of \(\frac{1}{10}\) and \(\frac{1}{3}\) is \[\square\].
11. Write the mixed number as an improper fraction.

\[
2 \frac{1}{4} = \square
\]

12. Multiply.

\[
\frac{3}{5} \cdot \frac{3}{1} = \square
\]

(Simplify your answer. Type a whole number, proper fraction, or mixed number.)

13. Write the decimal in standard form.

sixty-three hundredths

Sixty-three hundredths in decimal notation is written as \square. (Type a decimal.)

14. Round to the nearest tenth.

179.243959 rounded to the nearest tenth is \square.

\[
179.243959
\]

15. Multiply.

\[
\begin{array}{c}
0.896 \\
\times 0.7 \\
\hline
0.896 \\
\times 0.7 \\
\hline
\end{array}
\]

\[
\square
\]

16. Write the ratio as a fraction in simplest form.

$80 \text{ to } $70

$80 \text{ to } $70 is \square.

(Type the ratio as a simplified fraction.)
17. Simplify the following rate.

\[
\frac{50 \text{ gallons}}{6 \text{ weeks}}
\]

The rate is \(\square\) gallons \(\square\) weeks.

18. Find the missing number in the proportion.

\[
\frac{1}{8} = \frac{n}{16}
\]

\(n = \square\)


90 ft = \(\square\) in.

90 ft = \(\square\) in.

20. A tank of gasoline contains 14 gal. How many quarts is this?

14 gal = \(\square\) qt

21. During an experiment, the following times (in seconds) were recorded. Find the mean.

6.8, 5.9, 6.5, 3.7, 5.9, 6

The mean is \(\square\).

(Simplify your answer. Type a whole number or decimal rounded to the nearest tenth as needed.)

22. Find the mean for the list of inches of rain per month.

1.7, 1.6, 3.4, 7, 5.9

mean = \(\square\) inches

(Simplify your answer. Type a whole number or decimal rounded to the nearest tenth as needed.)
23. What is the median of the following list of numbers?

8.6, 9.2, 8.9, 9.5, 10.9

- A. 8.6
- B. 10.9
- C. 9.2
- D. 8.9

24. Classify as an integer, a rational number, an irrational number, and/or a real number.

\[-0.111...\]

<table>
<thead>
<tr>
<th>Number</th>
<th>Integer</th>
<th>Rational Number</th>
<th>Irrational Number</th>
<th>Real Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>(-0.111...)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

25. Translate to an inequality. Use the variable \(x\).

The adult's ticket price applies to those who are more than 15 years of age.

The inequality is \(\square\). (Type an inequality.)

26. A person borrowed $2800 from his home equity line of credit to pay off his car loan. He then borrowed another $1400 to have his kitchen repainted. How much does the person owe on his home equity line of credit?

The person owes $\square$ on his home equity line of credit.

27. Divide.

\[-\frac{14}{15} \div \left( -\frac{7}{5} \right)\]

\[-\frac{14}{15} \div \left( -\frac{7}{5} \right) = \square\]

(Type an integer or a simplified fraction.)
28. Combine like terms.

\[ 1.4x - 3.7y - 4.4x - 6.8y \]

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

○ A. The expression can be simplified. The simplified version is \square.

(Use integers or decimals for any numbers in the expression.)

○ B. The expression cannot be simplified.

29. Solve. Check your solution.

\[ \frac{-21}{29} = x + \frac{5}{29} \]

\[ x = \square \] (Type an integer or a fraction.)

30. Solve the equation for \( x \).

\[ \frac{4(x + 3)}{5} = 2x - 4 \]

\[ x = \square \] (Type an integer or a fraction. Simplify your answer.)

31. Subtract.

\[ (9y^2 + 8y - 4) - (-4y + 7) \]

\[ (9y^2 + 8y - 4) - (-4y + 7) = \square \] (Simplify your answer.)

32. Multiply vertically.

\[ (x^2 - 5x + 9) (7x^2 - 9x - 5) \]

\[ (x^2 - 5x + 9) (7x^2 - 9x - 5) = \square \]

(Simplify your answer.)

33. Write in decimal notation.

\[ 5.3 \times 10^{-7} \]

\[ 5.3 \times 10^{-7} = \square \]
34. Factor.

\[ x^2 + 5x + 4 \]

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

○A. \( x^2 + 5x + 4 = \) [ ]

○B. The polynomial is prime.

35. Factor completely.

\[ x^3 - 5x^2 + 6x - 30 \]

Select the correct choice below and, if necessary, fill in the answer box to complete your choice.

○A. \( x^3 - 5x^2 + 6x - 30 = \) [ ]

○B. The polynomial is prime.
1. Two thousand five hundred eighty

2. B

3. $9^5$

4. $1, 2, 3, 4, 6, 12$

5. A, 0

6. $\frac{3}{4}$

7. $\frac{7}{34}$

8. $4, 8, 12, 16, 20$
   $10, 20, 30, 40, 50$
   $20$

9. 392

10. 30

11. $\frac{9}{4}$

12. 12

13. 0.63

14. 179.2

15. 0.6272
16. $\frac{8}{7}$
17. $\frac{25}{3}$
18. 2
19. 1080
20. 56
21. 5.8
22. 3.9
23. C
24. No
25. $x > 15$
26. 4200
27. $\frac{2}{3}$
28. $A, -3x - 10.5y$
29. $\frac{26}{29}$
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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</thead>
<tbody>
<tr>
<td>30.</td>
<td>( \frac{16}{3} )</td>
</tr>
<tr>
<td>31.</td>
<td>( 9y^2 + 12y - 11 )</td>
</tr>
<tr>
<td>32.</td>
<td>( 7x^4 - 44x^3 + 103x^2 - 56x - 45 )</td>
</tr>
<tr>
<td>33.</td>
<td>( 0.00000053 )</td>
</tr>
<tr>
<td>34.</td>
<td>( A, (x + 1)(x + 4) )</td>
</tr>
<tr>
<td>35.</td>
<td>( A, (x - 5)(x^2 + 6) )</td>
</tr>
</tbody>
</table>