

Department of Mathematics

Topic: Support for students in high enrollment courses

Summary: We traditionally have assumed that high quality means low student-faculty ratios and that large lecture/presentation techniques are the only low-cost alternatives available to us. However, new models are emerging, such as those developed through the National Center for Academic Transformation (NCAT) <http://www.thencat.org/Monographs/ImpLearn.html>, that show it is possible to improve learning while simultaneously reducing the cost of instruction. In partnership with more than 60 colleges and universities, the NCAT has shown how using information technology to redesign courses can improve student learning while reducing instructional costs. Each participating institution has found that success depends upon collaboration among faculty members, professional staff and administrators. Some of the characteristics of successful course redesign include:

- The whole course—rather than a single class or section—was the target of redesign;
- All redesign projects used more active and more learner-centered instructional methods;
- Instructional software learning resources were used to engage students with course content; student pacing and progress were organized by the need to master specific learning objectives, which were frequently in modular format, according to scheduled milestones for completion;
- An expanded support system gave students assistance from a variety of different people;

Based on the research and model from the University of Missouri-Kansas City (UMKC), Supplemental Instruction (SI) targets difficult gateway courses as opposed to targeting high-risk students. After a high risk course (30% of students receive grades of D, F, W) is identified, a SI leader is hired based on his or her grade in that class and the recommendation of the professor or the departmental graduate administrator. SI leaders are trained in non-directive leadership skills, group process skills and learning skills.

Annually, over 3,000 students enroll in Math 1065, College Algebra, a course which is characterized as a gatekeeper course at ECU with DWF rates around 33%. In this white paper, we illustrate how a redesign of Math 1065 or enhanced SI could substantially lower the DWF rate, thus contributing to the important goals of retention and progression of students towards graduation.

Student Learning: The Department of Mathematics is exploring the possibility of redesigning the delivery of MATH 1065, College Algebra, using a model initially developed by Louisiana State University, Virginia Tech, the University of Alabama, and the University of Idaho. These redesign projects involve moving from a push strategy, which presents all material to all students in the same way and at the same time regardless of their particular needs, to a pull strategy. The primary goal is to shift students from a passive, note-taking role to an active learning orientation in order to enhance learning. NCAT puts it this way: “Students learn math by doing math, not by listening to someone talk about doing math”.

In our proposed redesign, students will meet with an instructor one hour a week in a traditional lecture setting and will spend an additional three flexible hours a week in an instructor and tutor staffed learning lab. During the one hour traditional lecture the instructor will connect topics and concepts, work examples pointing out common student errors and misconceptions, re-enforce concepts that are more challenging for the students, and guide students through their semester responsibilities. Challenging concepts are indicated by assessment data generated by MyMathLab, assessment data from previous finals, and knowledge from experienced instructors. During the three flexible hours in the math learning lab students will use MyMathLab to work through weekly modules and their accompanying quizzes. The modules and quizzes provide repeated opportunities for practice exercises accompanied by individualized feedback. While working on a module, if a student needs help, an on-site faculty member or tutor can provide immediate one-on-one assistance.

This model also has the added advantage of customized instruction that most often is not seen in the traditional lectures. Students differ in the backgrounds they bring to the course. MyMathLab will allow students to access the material they need when they need it, an approach that takes into account differences in learning styles and abilities. MyMathLab helps to identify areas where a student lacks knowledge, and will automatically direct the student to spend more time on these areas instead of spending equal time on all areas, which is most often what occurs in the traditional classroom. This customized instruction leads to more focused time on task as well as higher levels of learning. Also, MyMathLab has excellent tracking features, which allows faculty to ensure all students are on track.

We plan to model our course redesign after that of Louisiana State University. Prior to the development of this program at LSU, the fall ABC success rate for College Algebra averaged around 64% with a 14% withdraw rate. After running a semester pilot and several semesters of combinations of delivery methods and making improvements to the course design, the Fall 2006 results for College Algebra were remarkable: a record low drop rate of 6%, the final exam median of 78% and the highest ever ABC success rate of 75% were achieved. In contrast, ECU has a current ABC success rate of 67% using the traditional classroom based approach.

Other institutions now using similar designs for mathematics are UNC at Chapel Hill and Greensboro, Georgia State University, Ole Miss, Wayne State University, the University of Arkansas, the University of Nebraska, Oklahoma State University, the University of Central Florida, Auburn University, and Southeastern Louisiana University. Other disciplines involved in NCAT redesign programs include Spanish, English, Biology, Chemistry, Statistics, and Psychology.

At its core, pedagogies underpinning these redesigns leverage constructivist theory. Most pedagogical approaches that have grown from constructivism suggest that learning is accomplished best using a hands-on approach. Learners learn by experimentation, and not by being told what will happen. The teacher's role is not only to observe and assess but to also engage with the students while they are completing activities, and to intervene when there are conflicts that arise; however, they simply facilitate the students' resolutions and self-regulation, with an emphasis on the conflict being the students' and that they must figure things out for themselves.

The report *Making the Grade: How to Improve Your MyMathLab Implementation through Personalization and Best Practices* (<http://www.mymathlab.com/making-grade>) discusses best practices that drive course redesigns and provides actionable blueprints for replicating redesign successes. NCAT's website also contains a wealth of information on redesign, including several case studies of successful course redesigns of introductory math and stats courses.

Significance and Urgency: Major goals for redesigning Math 1065 are to improve student success, increase learning and to accommodate varying levels of preparation, math anxiety, and diverse learning styles, while simultaneously lower instructional costs. Over the past three years, a total of 10,428 students enrolled in College Algebra, which averages to about 3,500 students per year. Of these 10,428 students, the ABC rate was 62%, which translates to roughly 4,000 students making D's or F's over that three year period.

Term	A	B	C	D	F	Total
Spring	386 10.50%	653 17.76%	903 24.56%	603 16.40%	1132 30.79%	3677
Summer I	56 17.07%	75 22.87%	96 29.27%	40 12.20%	61 18.60%	328
Summer II	44 15.38%	67 23.43%	82 28.67%	39 13.64%	54 18.88%	286
Fall	1204 19.62%	1539 25.08%	1428 23.27%	816 13.30%	1150 18.74%	6137
Overall	1690 16.21%	2334 22.38%	2509 24.06%	1498 14.37%	2397 22.99%	10428

It is self-evident that improved student performance in Math 1065 would be most beneficial to ECU's retention rates, as well as its students' progression towards graduation. Indeed, Math 1065 can be characterized as a gatekeeper course. Universities that have redesigned math courses benefited from increased student performance, as indicated in the following table:

College	Course	Traditional ABC rate	Redesign ABC rate
Virginia Tech	Linear Algebra	81%	87%
U of Alabama	Intermediate Algebra	40%	78%
U of Idaho	College Algebra	59%	74%
UNC-Greensboro	College Algebra	38%	51%
LSU	College Algebra	64%	75%

Many other universities also made significant gains in their ABC rates by redesigning introductory math courses. In order to improve retention rates, student learning as well as the

quality of learning, statistics show that substantial positive gains could be made by redesigning College Algebra at ECU.

Description and Scope: The course redesign of College Algebra will follow the Replacement Model, one of the six models suggested by the National Center for Academic Transformation (NCAT). The replacement model reduces the number of in-class meetings and replaces some in-class time with out-of-class, online, interactive learning activities. Such activities should move students from a more passive, note-taking role to an active-learning orientation. Thus, students will learn math by doing math and not just watching someone else do math.

We would initially follow the model developed by Louisiana State University. Currently, our students spend three hours per week in a traditional classroom setting. With the new model, each college algebra student would be required to attend a fifty-minute class once a week at a scheduled time and spend a minimum of three flexible hours that week in a lab setting. The goal of the weekly class meeting is to help students focus on upcoming tasks by guiding them, pulling more difficult concepts together and helping them avoid common mistakes made in math problems. Instructors might: recap previous material, give an overview of new material, work difficult example problems, show examples of problems that combine multiple skills, review due dates, and discuss strategies for studying. While students are in the lab, they will complete homework, quizzes, tests and the final exam online using the web-based learning and assessment system MyMathLab and the College Algebra e-book written by Kirk Trigsted.

Trigsted's e-book may be purchased in a guided notebook format. **The Guided Notebook** is an interactive workbook that guides students through the course by asking them to write down key definitions and work through important examples for each section of the eText. The e-book has a completely clickable interface, has a computer-friendly layout and is filled with review links, animations and videos. In addition, Trigsted's program maps each section's activities to reinforce conceptual understanding before students tackle homework.

Currently, a few of the College Algebra instructors have been using MyMathLab for homework and/or quiz purposes. Those individuals have been pleased with the product itself as well as the help it provides for students. Many schools that use MyMathLab are reporting higher pass rates and higher retention rates. Once the redesign is implemented, all students will use MyMathLab. By using this on-line program, students are able to:

- Practice and learn mathematics when and where they want, and at their own pace .
- Work through unlimited tutorial exercises correlated to the exercises in their e-book and get immediate feedback on their answers.
- Receive a personalized study plan to diagnose areas where they need to practice.
- Access a multimedia e-book with links to learning aids, such as animations and videos.
- Use online tools, such as a discussion board or virtual classroom, to communicate with instructor and/or other students.
- Feel as if they have their own personal tutor, always available, and dedicated to their success.

In addition to the resources available through MyMathLab and the Trigsted book, students can also access materials created by College Algebra instructors. Dr. Drew Butcher has created numerous videos corresponding to the course objectives and set up a website where these can be viewed (<http://drewbutcher.wordpress.com> and www.youtube.com/ecumath). Beth Andrews and Darlene Worthington are participating in an Avatar program created by Dr. Nasseh Tabrizi from the Computer Science department. This program is a course management system that uses 3-D technology, a whiteboard and PowerPoint slides to present material to the class. Class lectures are recorded in a virtual classroom. These lectures can then be recorded and viewed at a later time; they may be used as a student help aid or in an online class.

During the academic year, the computer lab will be open for twelve hours per day or for sixty hours per week. The lab will be staffed with a mixture of instructors, graduate students and undergraduate students. At any given time, three persons will be present, resulting in one hundred eighty hours to be covered. The lab manager or course coordinator will provide twenty hours of supervisory coverage, while an additional twenty hours of supervisory coverage will be provided by those faculty members teaching College Algebra. Thus, the amount of student coverage needed weekly will be one hundred forty hours. Seven graduate teaching assistants will staff the lab for eighty four of those hours leaving fifty-six hours to be covered by undergraduates. This model may also be enhanced by incorporating supplemental instruction (SI) based on our successful partnership with the Department of Human Ecology.

ITCS will be heavily involved in the implementation of course redesign. At this time, we do not have a large enough space to house the lab. During the Fall 2010 semester, there were 2,021 students enrolled in College Algebra. During the spring semester, there are 1,145 students. NCAT's rule of thumb is: the number of computers required = the number of students/11 if testing is done in the lab. Using this model, we would need one hundred eighty-four computers. This number could be reduced by offering fewer sections in the fall and more in the spring. If we made that change, using our current numbers we would then need one hundred forty-four computers.

Another factor involved in the implementation of course redesign is to provide training to the instructors and tutors. A new philosophy of teaching is required in order for the redesign to be successful. The instructor is no longer the "sage on the stage" but a "tutor in the trenches"; he becomes a facilitator of student learning. The tutors also need to be coached in how to facilitate and engage students in problem-solving rather than in resorting to lecturing or providing answers to students. NCAT offers these tips:

- Plan to get instructors involved as early as possible (decision-making)
- Offer workshops with presentations and discussions (course redesign as well as MyMathLab)
- Bring in guests from schools that have successfully implemented course redesign or arrange for visits to those schools
- Meet frequently during the semester to discuss suggestions, problems, etc.

Assessment: One of the Foundations Goals of the Mathematics Department is that students in foundations curriculum courses will learn Mathematics that is appropriate to their background and educational needs. Since Fall 2008, student performance on the common final exam in College Algebra has been analyzed each semester by assessing student competence in the following areas: Lines, Solving Equations and Inequalities, Word Problems, Graphs, Exponentials and Logarithms, Functions and Basics. Our most recent data (provided by Dr. John Crammer) is:

Fall 2010 (top) competency by concept area (With Fall 2009 in the middle and Fall 2008 in parentheses)

1743 students took the common final exam.

	# questions	Outstanding competence (A)	Strong competence (B)	Reasonably consistent competence (C)	Developing competence (D)	Incompetence /Occasional Competence (F)
concept area						
Lines	3	42.05	-	-	31.21	26.74
	3	33.51	-	-	36.13	30.36
	(4)	(30.65)	-	(35.23)	-	(34.12)
Solve equations and inequalities	9	19.05	21.29	18.53	14.63	26.51
	9	13.31	21.27	20.58	17.53	27.31
	(7)	(8.21)	(18.54)	(21.66)	-	(51.59)
Word problems	7	17.10	17.67	16.35	12.57	35.92
	8	13.25	18.87	19.45	17.42	31.00
	(7)	(8.32)	(16.25)	(18.59)	-	(56.84)
Graphs	11	15.78	17.21	15.15	15.09	36.78
	7	6.25	13.84	22.77	-	57.14
	(6)	(12.52)	(21.83)	-	(23.56)	(42.04)
Logarithms and Exponentials	8	9.93	23.18	20.88	18.13	27.88
	10	17.96	15.45	15.50	13.84	37.25
	(10)	(13.29)	(14.96)	(16.58)	(13.96)	(41.21)
Functions	8	15.15	23.52	20.60	15.20	25.53
	8	7.91	16.78	20.42	20.74	34.15
	(9)	(4.97)	(9.32)	(13.66)	(18.59)	(53.43)
Basics	4	19.16	-	29.37	-	51.46
	4	10.58	-	27.53	-	61.79
	(5)	(14.01)	(27.08)	-	(29.54)	(29.37)

Note: Some of the areas overlap (i.e., a question can be in more than one area).

(Note: Fall semester scores are compared with Fall and Spring semester scores are compared with Spring; final exam averages are typically about five points lower during the Spring semesters.) These areas will continue to be assessed by using a common final exam and the results will be compared to data collected from traditional sections from the three previous years. In addition, Dr. John Crammer has provided the following statistics for each of the four versions

of the final exam: question analysis, percent correct for each question by topic, and frequency distribution. Each of these will continue to be compared each semester.

At the beginning of each semester, Dr. Crammer has met with the College Algebra instructors to discuss the assessment results from the previous semester. Strengths and weaknesses are determined and discussed. Instructors share different techniques they have used in their classes – those that work well and those that did not. Recently, Dr. Crammer has shared an End of Course Memo with us. Each instructor has the opportunity to anonymously share his/her own thoughts concerning assessment of personal changes in the course, concerns regarding students' backgrounds and learning, and curriculum issues. Once completed, Cathy Wilkerson (College Algebra coordinator) will compile this information and share it with all of the instructors. We will continue to do this at the end of each semester.

Individual instructors will assess their students' learning with MyMathLab, a powerful on-line homework and test manager. Students can complete homework, quizzes and tests with this program. Interactive tutorials are available and students get immediate feedback. At this time, the required homework for College Algebra has been mapped from our current textbook to MyMathLab. This mapping will need to be completed with the adoption of a new textbook.

A survey will be administered to students at the end of each semester to determine their perceptions of MyMathLab and the redesign of the course. Students will be asked whether they strongly agree, agree, are neutral, disagree, or strongly disagree with given statements. Examples of statements are:

- MyMathLab decreased my level of anxiety towards math.
- MyMathLab was easy to use.
- MyMathLab helped me understand the mathematical concepts presented in this course.
- If I were to take another math course, I would benefit from using MyMathLab.
- In general, MyMathLab made learning more interesting.

Schedule: A large-scale course redesign using information technology involves a partnership among faculty, IT staff, and administrators in both planning and execution. Substantive changes in the way courses are offered cannot rely on faculty initiative alone. They are systemic and involve changes in such institution-wide areas as policy, budgeting, administrative procedures, and infrastructure. Institutional policy regarding things such as class meeting times and contact-hour requirements will require revision.

An appropriate space large enough to host a dedicated lab to support the redesign of Math 1065 must be found, and funding must be made available to equip the lab with the necessary furniture, and computers. An administrative initiative is required to bring development opportunities to the attention of the wider faculty and to provide the infrastructure and support to enable people to commit their time to course redesign. While the facility is constructed, a team of faculty will start to develop methods and materials to be used in the lab. Curriculum oversight committees must learn to expect and encourage innovative course designs that break the traditional mold by

providing flexible scheduling and contact requirements. These initial activities will take place in 2013-2014.

In 2014-2015 we plan to pilot the redesigned course with several sections in the new lab, and learn from our experiences to move to a full implementation in 2015-2016 and 2016-2017. Students will meet with their instructor in the classroom for one hour per week and will be required to spend an additional three flexible hours in a teacher- and tutor-staffed learning lab. In the classroom, teachers connect topics and concepts, work examples pointing out common student errors and misconceptions, and help to guide students through their semester responsibilities. In the math learning lab, help will be available 60 hours a week. There teachers and tutors give students immediate, personalized help with math concepts and skills. This model emphasizes an active approach to learning mathematics, instead of just passively observing someone else doing mathematics. The repeated opportunities provided by MyMathLab for practice exercises accompanied by specific, individualized feedback promote mastery of each new concept. All assessments are delivered using specialized software called MyMathLab. Homework, quizzes, and tests are taken using exercises algorithmically generated by the software. Help and Example buttons guide students through the homework, and the textbook and streaming videos can be accessed through the software as well.

Risk assessment: The report *Making the Grade: How to Improve Your MyMathLab Implementation through Personalization and Best Practices*

(<http://www.mymathlab.com/making-grade>) discusses best practices that drive course redesigns and provides actionable blueprints for replicating redesign successes. Moreover, several ECU faculty have extensive experience in using MyMathLab to administer quizzes and homework in their math courses. The Chair of Mathematics, Dr. Johannes Hattingh, lead the redesign of College Algebra and Precalculus at Georgia State University during 2004-2008. A team of faculty will be visiting LSU in the beginning of February 2011 to learn about their redesign experiences. NCAT's website also contains a wealth of information on redesign, including several case studies of successful course redesigns of introductory math and stats courses. Given ECU's robust IT infrastructure and mature information technology support as well as our extensive experience with MyMathLab, we are confident that a redesign of Math 1065 poses a very low risk to ECU.

Commitment to and Support of the Topic: It will be very difficult to complete a large-scale redesign project without the enthusiastic support of faculty. In the recent response to the external review of the department, we voiced our unanimous support of exploring a redesign of Math 1065. The external reviewers pointed out that the university should re-examine the teaching of Math 1065 and other introductory courses and urged the department to explore the emerging NCAT models. The Harriot College of Arts and Sciences (HCAS) lists the redesign of Math 1065 as one of its strategic goals, within the broader context of student retention and progression towards graduation. Thus, we have the enthusiastic support of the faculty and the support of the HCAS in place.

Implementation Resource Requirements: The redesign of College Algebra will require a large investment of resources initially as the learning lab is constructed and outfitted with computers, appropriate software, furniture, and so on. But in addition to all the other benefits offered by the

redesign, it will also ultimately pay for itself within a few years due to savings in personnel costs, and the avoidance of wasted resources due to students having to repeat College Algebra.

The largest cost initially will be finding an appropriate space to house the learning lab. Assuming the lab is to hold 144 computers, space will need to be found and renovated to hold this large number of computers and the students who will be using them. There is currently no space available in Austin that would be suitable for the project. Other startup costs will include purchasing computers and the appropriate software for the learning lab.

We estimate these costs as follows:

1. 144 workstations @ \$1,000 each=\$144,000
2. Accutrack software license = \$6,000 (for tracking visits to the lab, and recording attendance)
3. Accutrack Weblink software = \$700 (for students to view, schedule and cancel test and final exam appointments via the web)
4. Two id readers (for use with accutrack software) = \$300
5. Screen with projector = \$2,000
6. Two printers = \$1,000

These fixed, initial costs total **\$154,000**.

There will be no increased personnel involvement in this effort. There will be some new costs associated with personnel as the redesign is implemented but there will also be considerable savings that will far outweigh these new costs. The lab will be open for a total of 60 hours per week and 3 persons will be present at any given time, resulting in 180 per week that need to be staffed. The lab manager/course coordinator will cover 20 of these hours and an additional 20 hours per week will be staffed by college algebra instructors. This leaves 140 hours that would still need to be covered. 7 graduate assistants would cover 12 hours per week each for a total of 84 hours while the remaining 56 hours would be staffed by undergraduates. The lab manager will likely be a fixed-term faculty member; assuming an annual salary of \$40,000 per year, the cost will be $.5 \times \$40,000 = \$20,000$. The department currently has enough graduate student funding to cover the costs of the 7 TA's. Assuming a rate of \$8.00 per hour for the undergraduates, the total cost for fall and spring semesters will be $30(\text{weeks}) \times 56(\text{hours}) \times \$8.00 = \$13,440$. Thus new personnel costs will be **\$33,440**.

But there will also be considerable savings in personnel costs. The Math Department currently offers about 72 sections of Math 1065 per year. A fixed-term faculty member teaching only Math 1065 would teach 4 sections per semester or 8 of these sections per year. Thus 9 full-time fixed term faculty members are required per year to teach Math 1065. Under the redesign, one section would require 1 contact hour per week in addition to time spent staffing the lab. So a fixed-term faculty member could teach 8 sections per semester or 16 per year. Thus 4.5 full-time fixed-term faculty members would be required per year to teach Math 1065. Again assuming an annual salary of \$40,000 per year, the savings in personnel costs would be $4.5 \times \$40,000 =$ **\$180,000**.

Total savings in personnel per year would be $\$180,000 - \$33,440 =$ **\$146,560**.

The redesign of College Algebra would require the far reaching involvement of many offices on campus. Academic Affairs would need to provide the resources necessary for the structure to house the learning lab and the computers and software needed for the lab. Facilities Services would need to be heavily involved in renovating the space for the learning lab. Also ITCS would set up the computers in the lab and install the appropriate tracking software. But this project is worthy of the involvement of these major offices. Not only will the quality of the learning experience in Math 1065 be improved, this model has the potential to be extended to other service Math courses taken by hundreds of students such as Elementary Statistics.

Available ECU Expertise: Several ECU faculty have extensive experience in using MyMathLab to administer quizzes and homework in their math courses. The Chair of Mathematics, Dr. Johannes Hattingh, lead the successful redesign of College Algebra and Precalculus at Georgia State University during 2004-2008. A group of faculty members that are well versed in the use of MyMathLab are traveling to LSU to learn about how they successfully used course redesign for College Algebra.

Plan Development Process: The report *Making the Grade: How to Improve Your MyMathLab Implementation through Personalization and Best Practices*

(<http://www.mymathlab.com/making-grade>) discusses best practices that drive course redesigns and provides actionable blueprints for replicating redesign successes. Moreover, several ECU faculty have extensive experience in using MyMathLab to administer quizzes and homework in their math courses. The current departmental chair lead the successful redesign of College Algebra and Precalculus at Georgia State University during 2004-2008. NCAT's website also contains a wealth of information on redesign, including several case studies of successful course redesigns of introductory math and stats courses. In the Fall of 2010, Pearson representatives gave a presentation detailing various modes of course redesign. Pearson provided literature and handouts that discuss various successful redesigns of introductory math courses in community colleges and universities across the nation. A team of faculty will be visiting LSU in the beginning of February 2011 to learn about their redesign experiences. The insight gained from this trip will be exceptionally useful to our program as we make the change as well. We are confident that these resources, in conjunction with our collective experience, will serve us well as we redesign Math 1065 at ECU.

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