FIRST YEAR EXPERIENCE OF A LARGE COURSE REDESIGN

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Introduction

In the fall of 2011, the president of Northern Arizona University set forth as a goal for the Department of Mathematics and Statistics at Northern Arizona University to begin offering several freshman-level mathematics courses in a "math emporium" setting. Essentially, this meant the content delivery for these redesigned courses would change from a traditional lecture course to one that would be web-based in nature, and students would spend a majority of their time in class working on the course content in a computer lab setting.

There are several advantages to using this setup for course delivery. One, it provides a learning atmosphere that is more active in nature; rather than passively listening to an instructor lecture about mathematics, the students are actively involved in acquiring that knowledge. Secondly, it allows students of differing abilities to progress at their own rate, and not at the instructor's pre-determined rate (Minotti & Giguere, 2003), within limits, of course. For example, if a student needs to spend little or no time on a certain concept because they already understood it, they could (rather than listening to a lecture discuss something they already knew). Conversely, if a student needs to spend extra time working on a concept, that is possible as well. A web-based format for content delivery allows for flexibility of use on the part of the students; they could work on the course materials whenever it fit into their schedule, not just during class meeting times. The location could be flexible as well; they could work on the course in the computer lab (the math emporium), in other computer laboratories across campus, in their residential halls, or in endless locations off campus, provided there were wireless Internet capabilities at those locations (Minotti & Giguere, 2003).

There was one additional reason the president of NAU wanted to make this change: retention of students. In recent years, the state of Arizona has been applying increasing pressure on NAU and the other two major universities in the state (University of Arizona in Tucson, and Arizona State University in Tempe) to increase the retention rates of first year students. At NAU, one of the ways this issue has been tackled has been by focusing on first-year courses that freshmen typically take that have high D/F/W (grades of D, F, or Withdraw) rates. During the academic year 2010-2011, four of the top eight courses in this category were courses in the Department of Mathematics and Statistics, including the two courses with the highest D/F/W rates in the entire university. Retention of first year students through this means is of particular importance, as studies have shown that students who fail an introductory/remedial mathematics course often never earn a college degree of any kind (Beaudrie, 2007). Therefore, it was apparent that a change was necessary.

Some Issues in Development

As the development team began their work, they realized there were several issues to be addressed. One overall issue that led to difficulties was the timeline established by the president. He insisted that these redesigned courses and lab be fully operational, with the capacity to serve approximately 2000 students by the beginning of fall semester 2012, giving the Department of Mathematics and Statistics a little less than one year to make all of this a reality. Among other things, this essentially meant that conducting a pilot test over a semester of any portion of the redesigned courses would not be possible. It also meant that research into possible models of operation that other universities and colleges were using would have to be conducted rather quickly, and by whomever in the department had the time to travel to sites employing this method of teaching math courses, whether they had any expertise in the methodology or not.

Each of the courses eventually selected for inclusion in this redesign had its own unique structure and characteristics. Therefore, there was not a 'cookie cutter' approach to the redesign of each, where a redesign method for one course would seamlessly transfer to another. Designing a schedule for each redesigned course was another issue that proved difficult to solve. Being able to create a schedule to ensure all students' needs were being met within their course (without the benefit of pilot testing the schedule to see how practical it would be) was quite a challenge.

Another issue concerned how to staff this new math emporium. It was recognized early on that undergraduate tutors and graduate teaching assistants (GTA's) would play a major role in the redesigned courses. It was also recognized that very few permanent faculty in the Department of Mathematics and Statistics would have the ability to participate in the

new math emporium due to their already existing responsibilities and commitments. Therefore, a bulk of the teaching duties would fall onto the shoulders of instructors, lecturers, and GTA's.

One of the major issues with the creation of the math emporium was where to house it. As this issue was investigated, it turned out that finding a single space on campus that would easily house enough computers and computing capacity for 2000 students (and getting it operational in less than one year) proved to be impossible. Instead, several rooms of the newest building on campus (the Health and Learning Center) were designated for use as the Lumberjack Mathematics Center until such time when an appropriate sized facility can be built. Although the rooms had to be modified in order to serve as computer labs, because they were new and had not been designated for any purpose as of yet, this proved to be the best solution in creating a space for what would be known as the Lumberjack Mathematics Center.

The Lumberjack Mathematics Center

The newly designed emporium was dubbed the Lumberjack Mathematics Center or LMC for short (the nickname of NAU's sports teams is the Lumberjacks). As mentioned earlier, the space for the math emporium, in the manner that most universities' used such a space, could not be created at NAU by the fall of 2012. Instead of having one or two large rooms for the emporium, it instead consists of seven smaller rooms in one wing of a building, the Health and Learning Center.

Six of the seven rooms were computer classrooms; one of these rooms is designated as a dedicated testing center, while the other five are used for class/lab time. One room was left as a classroom with no computers. Most of the computer rooms in the LMC are typical in size to the standard classroom, having room for approximately 30 computers, although one room does have slightly more than 50 machines. In the computer labs, there is plenty of space between the rows of computers, which allows for easy access by anyone assisting the students as they work; also, several tables that hold computers in the various labs, and the computers on these tables, are designed to accommodate learners with any type of disability.

During the Fall Semester, the LMC was open from 8:00 a.m. to 9:00 p.m. Monday through Thursday, 8:00 a.m. to 5:00 p.m. on Friday, and on Sunday from 2:00 p.m. until 9:00 p.m. From 8:00 a.m. until 2:00 p.m. Monday through Friday, the primary function of the LMC during the fall semester was to hold the regular meetings for the redesigned courses; from 2:00 p.m. until closing each day (and on Sundays), the LMC had open lab, when students from these courses can work on their materials. Each of the seven rooms

at the LMC (when open) are staffed with at least one, and usually two, instructors/tutors/GTA's. It should also be noted that only students who were enrolled in one of the redesigned courses were allowed to use the LMC. This area was dedicated for their use, and for their use on only the necessary course materials, as other web sites/access was blocked to help prevent the temptation of visiting email, social media sites, or other web sites that might be a distraction to the student's learning.

The Redesigned Courses

With certain enrollment criteria to be met (approximately 2000 students per semester), and a certain level of courses to be used in the emporium (only freshman-level mathematics courses), the choice of mathematics courses to place into the Lumberjack Mathematics Center (LMC) was fairly limited. Given the enrollment criteria, it was quickly decided that only those courses with large enrollments should be considered. The department wanted to keep the number of redesigned courses as small as possible, since redesigning many courses would more than likely be a very daunting task.

In the end, three courses were chosen for implementation: MAT 114: Quantitative Reasoning, MAT 108: Algebra for Precalculus, and MAT 100: Mathematics Pathways, a new course that would replace MAT 102X: Intermediate Algebra. Each course would approach the redesign in a slightly different way.

The only students who are allowed to enroll in the MAT 100: Mathematics Pathways are those who fail to place in a credit-bearing college-level mathematics course. The purpose of the course is to provide students with the mathematical knowledge necessary to either pass the Advancement Exam or obtain a sufficient score on the placement exam. Success on either exam would allow the students to place into a credit-bearing mathematics and/or statistics course. This course, while offered for two credits, would not apply towards graduation. This course was also offered as a pass/fail course, rather than a letter graded course.

In MAT 100: Mathematics Pathways, students must complete a minimum of 150 minutes of work in the LMC each week. At that minimum pace, it was determined that students should complete the course materials in one semester; but students were also encouraged to work at a faster pace, complete the course earlier, and (possibly) enroll in a late-starting MAT 108 (Algebra for Precalculus) course. Of the required 150 minutes, 100 minutes (two 50-minute class periods) are scheduled class meeting times; the other 50 minutes are to be completed in open lab time at the LMC, whenever the students had the opportunity.

The content of the Mathematics Pathways course consists of content typically found in a college-level Beginning and Intermediate Algebra courses. For this reason, it was decided that the semester-long MAT 102X: Intermediate Algebra would no longer be offered, as the MAT 100 course covered roughly the same material.

The Algebra for Precalculus (MAT 108) has been offered at Northern Arizona University since the fall of 2005. The course was designed as a replacement for College Algebra. The content of the course can be described as being a mixture of content from typical Intermediate Algebra and College Algebra courses found at most universities.

One of the reasons given for creating the Algebra for Precalculus (and to end College Algebra) was to eliminate duplication of topics; it was believed that there was too much repetition of content between the old College Algebra course and Precalculus. Therefore, the content of the new course was chosen to help better prepare students for the content of Precalculus, rather than simply giving them the exact same material. Another reason given for the new course was one concerning the population it would serve. The old College Algebra course was at that time part of the graduation requirements of several majors or minors, even though the course may not have been the best "fit" for those majors (a course in quantitative reasoning, for example, might be a better fit). So, the course attempted to cover a rather large number of concepts in order to satisfy these requirements. The new Algebra for Precalculus course was designed solely for those students who would need to continue on into Precalculus, and not to meet any graduation requirements of any other program of study. By streamlining the content of the course for that population, the study of those concepts could be conducted more deeply to allow for conceptual understanding.

During the initial semester in the emporium, the Algebra for Precalculus course would meet as scheduled three times a week for 50 minutes each. During two of those meetings, students would be working on course materials in a scheduled lab time. A third meeting would consist of class time where teachers could work with students in an activity-based setting, helping them make the higher-order connections within the content they are learning, connections that they may not be making by simply working out problems individually on a computer. Like the MAT 100 course, students in MAT 108 are also required to spend an additional 50 minutes outside of class time working in the LMC on course materials in the open lab.

Both the MAT 100 and MAT 108 courses are using the MyMathLab software package for course delivery. This product is used worldwide in several colleges and universities and has an impressive research base supporting it (Speckler, 2012). However, it was

decided that the MAT 114: Quantitative Reasoning course would not use MyMathLab. This course had recently made a change to incorporate WeBWorK into its course, and wanted to continue to use it to test its effectiveness before making a decision on whether to switch or not. According to its web site, WeBWorK is an open-source online homework system that comes with a National Problem Library of over 20,000 homework problems in mathematics and science topics. In addition to this, NAU professors and instructors spent several months creating WeBWorK problems and a course pack for this course to be used in the emporium-style MAT 114 course. Students enrolled in the Quantitative Reasoning course would meet twice weekly, once session as a scheduled 50 minute lab, the other in the classroom for a recitation section. Like the other two courses, the students in MAT 114 were also required to spend 50 minutes in open lab per week.

Some First Semester Issues

Despite several months of planning and preparation, there were two major last-minute issues that arose. Two weeks prior to the beginning of the semester, the NAU bookstore decided it should do the batch enrollments of all students into MyLabsPlus. Although they assured everyone that they could get the enrollments done before school began, this proved not to be the case. As a result, on the first two days of class, not a single student was enrolled in any redesigned MyLabsPlus course! The problem was rectified quickly, but it still led to much confusion on those first few days of the semester.

Approximately at the same time, the person hired to be the Lab Manager decided to quit. However, he did not inform anyone of his decision for a week or so, until the semester was about to start. So the beginning of the semester featured a very new Lumberjack Mathematic Center that no student could use. However since there was no lab manager to solve potential problems, it might have been a good thing! Despite this rough start, things did eventually get going, and a routine was established in the LMC.

As the semester progressed, it was apparent that despite the training, emails, and meetings, many GTAs did not understand the concept of a mathematics emporium set up and were giving students mixed information. Students in one section of a course would follow one set of directives (as told to them by their GTA), while students in a different section were following a different set. Despite many efforts to attempt to inform the GTA's that they shouldn't make up rules, and should check with those in authority first (such as the course coordinators and/or the Academic Director), this continued to be a problem throughout the entire fall semester.

Because of this setup of the LMC, it was known that staffing would potentially be an issue, as each room (when opened) must have at least one qualified person in it. Until the

courses began to operate, and a typical pattern of student work hours could be recognized, knowing how many people to have working at any one time would amount to guesswork. To help establish the schedule, other universities with an emporium setting were surveyed about the traffic patterns they had experienced. However, once the semester began, it was apparent that NAU students weren't following the same pattern.

For example, the busiest time for the open lab at NAU turned out to be Friday afternoons, which was contrary to what other universities experienced. Therefore, for the first few weeks of the semester, the lab was short-staffed on Friday afternoons, which resulted in students having to sit outside of the LMC in the hallway until enough staff could be found to open up another room (or they'd have to wait until someone logged off their computer). After a few weeks, once it became apparent that this was going to be the pattern, staff times were reassigned to ensure coverage of more rooms when necessary, thus solving this issue.

Results: D/F/W Rates

Table 1 below contains the average D/F/W rates for the previous five years (10 semesters) in MAT 102X: Intermediate Algebra (the course MAT 100: Mathematics Pathways replaced), MAT 108: Algebra for Precalculus, and MAT 114: Quantitative Reasoning, along with the D/F/W rates for Fall 2012 for the three redesigned courses.

Courses	D/F/W Rate Fall 2007 – Spring 2012	D/F/W Rate Fall 2012
MAT 102X/MAT 100	33.4%	30.1%
MAT 108	33.5%	43.9%
MAT 114	26.9%	21.2%

Table 1: D/F/W rates

A few comments on these results are necessary for full understanding. First, the MAT 114 course, although currently offered in the LMC, had a minimal "redesign" compared to the other two courses. It is very close in structure to what it was for several previous semesters before Fall 2012. During those semesters, the course had been offered as a hybrid course with one weekly one-hour lecture; students were then expected to work on their own on the projects and WeBWorK assignments. The only major difference in the course from previous semesters is that students were required to come to the LMC to work on their WeBWorK homework and their projects, rather than allowing them to do it on their own. This alone might account for the lowering in D/F/W rates for that course, as the students had assistance readily available to them (tutors) should they need it.

As for the MAT 108 course, the results for this course were worse, which can often happen in the first semester of a redesigned course. There are several possible reasons for this increase in D/F/W rate. It is difficult for both teachers and students to fully understand how, at first, to take advantage of the new method of course delivery. Once teachers understand how to best utilize the system, and students begin to understand the format of an emporium, results should begin to improve, which seems to happen at several other universities (Speckler, 2012). Another possible reason for the higher D/F/W rate might be the "all or nothing" structure of grading in these courses. In typical face-to-face courses (no matter what the course delivery style may be), the instructors will often grade problems giving partial credit to students for partially correct solutions. In the redesigned system, partial credit is not an option for most problems. It is either completely correct or completely incorrect. So, in theory, while students may not pass the course at a similar rate as before, those that do pass may be better prepared for their next mathematics course, which has been shown to occur at other universities (Witkowsky, 2008). This situation will be monitored in subsequent semesters to see if this proves true at NAU as well.

Another factor believed to lead to success in an emporium format is attendance and time spent working on problems in the MyMathLab system (Beaudrie, et., al., 2013). Figure 1 below shows the total number of hours, on average, students in MAT 108 put in for each grade earned.

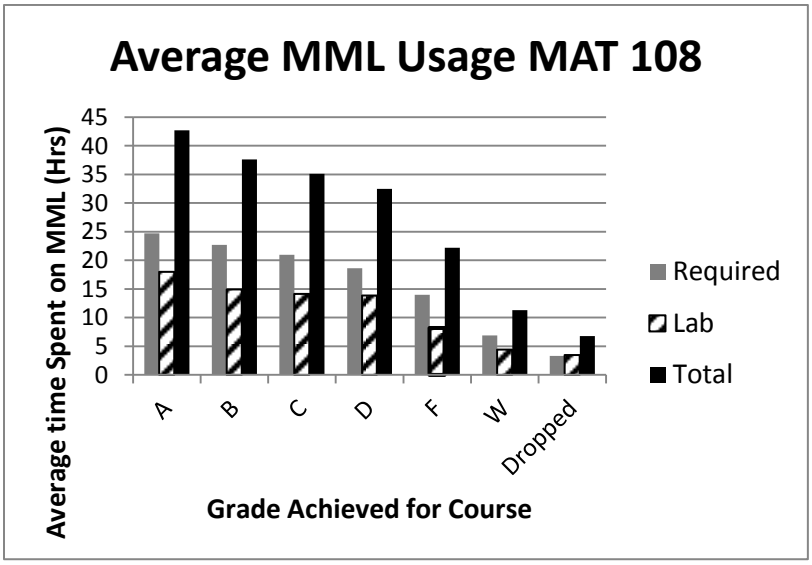

Figure 1: Average MyMathLab Usage based on grade earned in MAT 108

Note that the number of required hours (which refers to scheduled class meeting times) for the entire course works out to exactly 25 hours, while the number of lab hours for the course (which refers to the open lab requirement) is half that, at 12.5 hours total, for a total of 37.5 hours required for MyMathLab time in the course.

On average, those students who earned a grade of A in the course put in the necessary time working on the course materials in MyMathLab; they met the required course times (in other words, they rarely if ever missed class), and they went above and beyond when it came to working on problems in the open lab. Those students that earned a B were lower in both components when compared to their fellow students who earned the grade of A, but they still put in right around the total required time (37.5 hours), although with more than required time in open lab, and less than required in in-class scheduled lab time. This pattern continues throughout the earned grades.

Finally, although the decrease in D/F/W rates in MAT 100, when compared to its predecessor MAT 102X, is encouraging, passing the course is not the end goal of MAT 100; passing either the placement exam or the Advancement Exam by the end of the semester is the goal. This proved to have a much lower success rate, as illustrated in Table 2.

Result by End of Semester	Number of successes	Percent of successes
Passed Placement Test	96	13.0%
Passed Advancement Test	136	18.4%
Passed both	9	1.2%
Did not pass either test	500	67.5%

Table 2: Results of end-of-course testing in Mathematics Pathways

It should be noted that, of the 500 students who did not pass either test, 143 (28.6%) did not take either test. This number is large, but it still does not account for the vast majority of students who took an end-of-course test yet failed it. However, it does point to a possibility that many students were unaware of the courses' purpose: to prepare them to take (or retake) the Advancement or placement exam so that they could enroll in the next math course. It is believed that many students assumed passing the class was enough to advance. Efforts to increase communication between the instructors and students in this course were made in the spring semester in the hope to increase the percentage of students passing the placement tests. Finally, it should be noted that students were not required to take both end-of-course tests, though some students (at least nine) chose to do so.

Conclusion

Overall, this large course redesign went as well as anyone could have expected, given the size of the job and the short amount of time and resources allocated to make it work. While it would have been nice if the results were more encouraging, the current three courses, for the most part, showed expected results similar to what other redesign efforts have found. Several changes will be implemented in MAT 100 and MAT 108 with the hope of improving the success rate in those courses. Plans are in place to move a fourth course (Precalculus) into the LMC beginning in fall 2013.

Although the authors could make several recommendations based on the first semester's experiences, one significant one would be to make sure a pilot study can be part of any redesign effort, if possible. While a pilot study won't catch all potential problems, many situations that occurred during the fall semester would have been caught in a pilot study, and thus would have affected far fewer students. Due to that, the short amount of planning time and the lack of a proper space, it is believed that this course redesign has not come close to reaching its full potential. The authors believe that with the appropriate space and changes to course requirements, this course redesign effort will show similar results as the NCAT institutions.

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