Proposal of Changes to Mathematics Placement and Remediation

Department of Chemistry, Mathematics, and Physics

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Committee on Developmental Mathematics

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1 Introduction

In the spring of 2015 the Dean of the College of Art, Education, and Sciences approached the Department of Chemistry, Mathematics, and Physics about what he believed to be a high rate of failure in a developmental mathematics courses (MATH 050 and MATH 110), especially amongst first-semester students. The administration asked that the department explore initiatives and propose changes that could improve remediation, student retention, and success in these entry level classes.

In the summer of 2015 funding was provided for five individuals from the mathematics discipline to attend the Annual Meeting of the Mathematical Association of America (M.A.A.) in Washington D.C. They were tasked with attending presentations on initiatives taken by other universities and begin working on a plan of action. Dr.'s Karen Bolinger, Carey Childers, Duane Farnsworth, Michael McConnell, and Daniel Shifflet accepted the responsibility at the discipline's behest. In the fall of 2015 these individuals shared their new insights and ideas with the department and spearheaded the creation of the Committee on Developmental Mathematics.

Over the course of the 2015/2016 academic year, the committee met multiple times to investigate possibilities, share information, and discuss possible proposals. These activities included, but were not limited to:

- Performing analysis on data collected on students enrolled in these entry level classes over the past few years.
- Inviting representatives from publishers to present products to assist with mathematics remediation.
- Talking to colleagues at other universities about their procedures and the benefits and drawbacks.
- Researching potential alternative approaches like modularized and computer-based courses.
- Attending webinars on emporium and cohort models.

The analysis of our current model of mathematics placement and remediation has shown that it is not without merit. We found a positive relationship between an incoming student's S.A.T. Math score and the grade of their first remedial mathematics course [Table 1]. This provides evidence that using S.A.T. Math as one of the major contributers to our current placement system is a good indicator of success. We also found a strong relationship between a student's grade in MATH 050: Beginning Algebra and success in their subsequent mathematics course [Table 2]. This provides evidence that our most remedial course is having at least some success in preparing students who do well for the rest of their college curriculum. We also found that many of the students who performed poorly in MATH 050 also did so in subsequent mathematics courses and, anecdotally, other classes at the university. This implies that mathematics remediation is not the only barrier preventing many of these students from successfully completing their degree at Clarion.

The committee brings these points up now, not to imply that our current model is without shortcomings, but to emphasize that there are many factors contributing to a student's success in college. It is extremely rare that the mathematics requirement becomes the sole obstacle preventing an individual's graduation. Therefore, we would like to caution the reader that implementing even the most ambitious of proposed changes to mathematics placement and remediation may not be met with substantial success.

At the end of our analysis the committee did recognize areas in our current model where certain changes would be beneficial and perhaps even warranted. However, we also feel that change simply for the sake of change would be a colossal mistake. Successful modifications will require time or money (or both!). The mathematics discipline, of which the committee constitutes the vast majority, will enthusiastically contribute the requisite time, but only if the administration matches with sufficient long-term funding.

2 Mathematics Placement

The current mathematics placement system at Clarion relies heavily on a student's SAT Math score with some considerations made for most recent courses (with grades) taken in high school. It was developed out of need once funding to administer our home-made placement exam was cut. While there is some evidence of its effectiveness, the committee feels that this is the first, and most important, aspect of mathematics remediation that warrants attention.

2.1 List of Current Methods

When it comes to mathematics course placement for incoming college students, our analysis has shown there seem to be 4 popular approaches:

1. **No Placement Score:** Some schools do not issue students a placement score. They are permitted to enroll in the course that they are advised into for their major (or by a free-response placement test). However, this approach mainly occurs at large, public universities where coordination of placement testing would be extremely difficult and high failure rates of first-year students are not uncommon.

2. **Placement Based on S.A.T. Score or Similar:** Some schools, Clarion included, assign a placement score to students based on their mathematics standardized test score. While this technique is fairly quick and inexpensive, it does fail to see the "trees for the forest". By assigning students based on a single exam score, we are unable to identify their particular strengths and/or shortcomings. Students may get placed too low or high for their actual abilities.

3. **Coordinated Placement Exam:** Many mathematics departments have developed placement exams that they administer to incoming students during orientation visits and/or new student days directly before the semester begins. The department then has

the ability to grade these exams, identify each student's abilities, and properly place them into the correct class. While effective, this process does require the contribution of time and resources by the university to coordinate the taking and grading of these exams.

4. **Automated Placement Exam:** The final approach is to have a 3rd-party vendor administer their placement exam to the student remotely, then notify the mathematics department of the results. This allows the students to take the exam any time between their initial deposit to the university and the first week of classes. Further, the department does not have to coordinate grading of hundreds of exams.

2.2 The ALEKS System

While reviewing these options the committee has concluded that a change from our current model to an automated exam is the best for our students and our current funding circumstances. To this end the committee reviewed the unique placement testing options from McGraw Hill (known as ALEKS) [1]. It became quickly obvious that the ALEKS system would be able to meet all of our requirements of a placement exam process. Further, this same ALEKS system can be incorporated into lesson plans and homework for remedial mathematics courses, greatly reducing the time needed for students to become familiar with a new on-line supplement platform.

Summary of ALEKS placement exams:

- $25 per student
- can take exam up to 5 times
- student may complete remedial modules on their own time to increase their score on subsequent exams

As a possible future cost-saving measure, the committee has considered implementing hard cut-offs for students entering with certain standardized test scores. Using the data collected and our current placement model as a guide, we would automatically assign any student with SAT Math under 350 the lowest placement score possible and any student with SAT Math above 650 the highest score possible without having them take the placement exam.

An automated exam contains many benefits over our current model. First, it provides an opportunity to increase retention as students will be placed in the course that most matches their abilities. Second, motivated students who complete the review modules provided by ALEKS to improve their placement score will pay less by not having to enroll in extra remedial classes towards their requirement. Finally, the same ALEKS system can also be utilized as an on-line homework supplement in MATH 050 or 110. Since the students will already be familiar with the interface from their placement experience, this will cut down on the time required to learn the aspects of a new piece of technology.

The only drawbacks the committee can identify are small and acceptable. Obviously the flat fee for ALEKS is an added expense that our current model does not contain. However, we

feel that most students will greatly appreciate the option to study and retest on their own for no added cost. Second, ALEKS works best for students who register with the university early so that they have time to complete the remediation modules. Alternate advisement would have to be developed for students who do not officially register until the week(s) before the semester begins. Perhaps they would put-off taking their mathematics requirement until the spring semester. Finally, other departments would have to be educated on the changes being made and how they affect their advisees. Perhaps a seminar could be conducted with the department chairs and/or orientation representatives early in the first semester of implementation.

2.3 Time Line

To summarize, the committee recommends the university commit the funds to a 2-year pilot program of the ALEKS placement system to begin with at least a portion of the incoming class of 2017. The department would continue the current placement system over the course of this pilot program as a baseline comparison. After these 2 years the committee will review the results to be certain the new placement process is effective before possibly shifting the costs onto the students. With current enrollment projections a full-scale pilot would cost approximately $25,000 per year.

3 MATH 050 and MATH 110

While the Committee on Developmental Mathematics has found evidence that students who successfully complete MATH 050 and/or MATH 110 have more success in subsequent courses, we still feel that the curriculum of these courses is another area where a change may be beneficial. There is currently a great deal of overlap between the algebraic curriculum of MATH 050 and MATH 110. To some extent, this may be desirable. However, many of the algebra skills that are the focus of MATH 110 will not be needed in future classes taken by students in MATH 050. Furthermore, many MATH 050 students lack basic numeracy and have poor arithmetic skills, which exacerbates their difficulty with algebra. It is likely that in their past courses these problems were never adequately addressed because the instructors were expected to be teaching them algebra with little time to review or address these basic skills. Repeating those experiences in a university setting which is faster paced and where there is a greater expectation for students to be responsible for the own learning seems doomed to failure. The MATH 050/110 Curriculum Subcommittee was formed to address these concerns.

3.1 Challenges

There are a number of challenges faced by instructors and students in MATH 050 and 110. It is important to be aware of these challenges so that we can be realistic about what we as instructors or as a university can do to improve the prospects and experiences of students

in our developmental mathematics courses. The following is a list of some of the challenges faced by MATH 050, 110, or any bottom-tier remedial mathematics course:

- Many of the students are not college ready. They lack basic time-management and study skills.
- Students in MATH 050 and 110 are often nontraditional students or students with difficult financial problems who must work at a job a substantial number of hours each week. These students often lack both the time and resources necessary to successfully complete the course. Some students cannot afford the textbook, let alone a personal tutor.
- Many of the students who fail the course have poor attendance initially, and eventually stop attending completely.
- A typical MATH 050 or 110 class has students with extreme variations in terms of their abilities and their deficiencies. Some deficiencies are truly frightening. For instance, some students struggle with knowing their multiplication tables and others cannot add the simplest fractions.
- Some students have seen the material previously (perhaps multiple times) and think they know it (when, in fact, they do not). This leads to skipping classes and assignments, thus falling behind to a point at which they can not recover.

3.2 MATH 050 and MATH 110 in their Current Form

Currently MATH 050 and 110 are largely taught by temporary faculty using textbooks which were adopted by the department at some point in the past [2], [3]. Based on an informal survey of those who have taught the course and who know others who have taught the course, we propose that the following provides an outline of topics that have recently been covered in most sections of MATH 050 and 110.

MATH 050: Beginning Algebra

- Basic Arithmetic - whole numbers, rational numbers, real numbers, algorithms, exponents, order of operations
- Applications of Basic Arithmetic - proportions, ratios, percents, geometry, word problems
- Linear Equations and Inequalities - variables, solving linear equations and inequalities, applications
- Polynomials and Functions - graphing, operations, factoring, the function concepts, quadratics

MATH 110: Intermediate Algebra

- Linear Equations and Inequalities - variables, solving linear equations and inequalities, applications

- Polynomials and Functions - graphing, operations, factoring, the function concepts, quadratics
- Radical and Rational Expressions - nth roots, combining and simplifying numerical and variable expressions with square roots, simple rational expressions
- Quadratic Equations and Inequalities - graphing, solving, modeling

3.3 Proposed Changes to MATH 050

Given the analysis above, the committee has identified weaknesses in MATH 050 to be addressed. The goal of the new curriculum proposed below is to improve numeracy and basic arithmetic skills to a greater degree than is currently done. These skills will be reinforced and motivated through application problems encountered throughout the course. This proposed curriculum will also serve to alleviate much of the overlap in material between MATH 050 and MATH 110. Additionally, the committee has found that many students taking MATH 050 move on to take MATH 111, 112, or 221, rather than MATH 110 as previously thought. The program below will better emphasize content relevant to such courses [4]. Finally, since the proposed curriculum is still not considered "college level" by the committee, we feel that the MATH 050 label should continue to be used.

Unit 1: Arithmetic[1]

- Whole number arithmetic, number sense, and estimation
- Integer arithmetic with applications that motivate the arithmetic rules
- Fraction arithmetic with applications that motivate the arithmetic rules
- Decimals and a review of the algorithms for efficient base ten calculations for two and three digit numbers.
- Defining and working with exponents of the form c^n where c is a specified constant
- Taking square roots of perfect squares and simplifying/combining square roots of integers
- Order of operations

Unit 2: Quantitative Reasoning

- Reading Statistical Graphs and Charts
- Very basic probability and statistics
- Linear equations as models and linear regression
- Basic geometry
- Unit conversions

[1] It will be departmental policy that there shall be no use of calculators on any assessment of the material in this unit.

Unit 3: Algebra

- Using variables and combining like terms
- Solving linear equations and inequalities
- The notion of a function
- Graphing linear equations and inequalities
- Rewriting expressions with integer exponents
- Adding and multiplying polynomials
- Working with radical expressions that have variables

One possible future benefit of this proposed curriculum is a more modular sequence of remedial classes [5]. This way students would only have to take the sections of the course their placement requires. The committee has discussed some possibilities to consider, but a finalized proposal cannot be made until the curriculum becomes formalized and practiced. Traditionally this entire course would run 15 weeks, 3 days per week, for 3 credits. However, for students who have sufficient arithmetic skills we could envision combining units 2 and 3 into a course that would run 7 weeks, 4 days per week, or 15 weeks, 2 days per week for 2 credits.

Time Line

As the committee has found no suitable textbook aligning with this proposed curriculum, we will have to write our own over the 2016/2017 school year. This new text can then be implemented on a trial basis for the 2017/2018 school year with revisions to the curriculum occurring between semesters. Full implementation and possible modularization would then be possible for the 2018/2019 school year.

Example Application Problems

The committee has already begun the process of researching a more robust, application-based curriculum. Some possible examples are provided at this time for context.

Practicing with Percentages (Arithmetic, Unit 1): Suppose you worked for the PR department at the Department of Energy in 2007 when these data were released. Write a few sentences that put these data in the best possible light, supporting President Bush's energy policy. Suppose you worked for an environmental group that advocates for more support for renewable energy sources like wind. Write a few sentences that put these data in the worst possible light, supporting your argument that we are falling further behind the rest of the world. Suppose you work for a newspaper and are writing a story about these data. Write the opening paragraph and headline.

Fast Food and Obesity (Quantitative Reasoning, Unit 2): There is a negative correlation between the distance from a high school to the nearest fast food restaurant and the obesity rate of the students at that school. Sketch a scatter plot that reflects this information (make

up the data, subject to the above information). What does each dot represent? What does the x-axis represent? What are the units? What does the y-axis represent? What are the units? What does the slope of the line of best fit mean? What does the y-intercept mean? the x-intercept? Will they be positive or negative?

Pretend you are a high school principal. Make an argument against building a new fast food restaurant across the street from your high school. Pretend you are a restaurant owner. Make an argument why you should be allowed to build your restaurant across the street from the high school. Pretend you are a researcher. Now that you know the negative correlation, what further questions do you want to explore? What sort of study would settle the differences between the two argumentative people above?

The New Car (Algebra, Unit 3): I just bought a new car last year for $23,000. This year a used version is worth roughly $19,000. If the car continues to depreciate at this rate in the future, can you give me a formula to calculate the car's value after a certain number of years? Another way to consider this problem is that the car is now worth roughly 82.6% of its original value. Perhaps next year it will only be worth 82.6% of its current value. If this trend continues, can you give me a different formula to calculate its value? Which formula seems like a better predictor 7 years in the future?

3.4 Proposed Changes to MATH 110

While it was first-semester students' grades in MATH 110: Intermediate Algebra that initially caught the eye of the administration and set the wheels of this proposal in motion, the committee does not feel that this course requires any significant changes at this time. Unlike MATH 050, MATH 110 is a named prerequisite for courses that require a basic understanding of algebra - MATH 131: Applied Finite Math, MATH 171: Precalculus, and MATH 232: Calculus of Business I. The content of this course, therefore, must continue to focus on developing students' familiarity and understanding of basic algebraic techniques. The committee reviewed multiple texts on the subject, attended presentations at conferences on content suggestions, and researched alternate delivery methods. Our conclusion is that the course would benefit from a minor refocusing of the material to that which is most relevant to these subsequent courses listed above. Additionally, we feel that the proposals outlined above to the placement process and MATH 050 will help promote retention and increase success in MATH 110.

3.5 Further Recommendations

- If the committee's recommendation to utilize the ALEKS system for mathematics placement is realized, then we further recommend incorporating this same adaptive learning system into the MATH 050/110 curriculum. Students will already be familiar with its interface and it has the ability to keep students "engaged and on track" in the class (slowing down for poor students and speeding up for better students).
- Given the issues faced by students and instructors in MATH 050, the late afternoon

start times and two-day-a-week meeting schedule which is currently the norm is far from ideal. It is recommended that lecture be on a three-day-a-week schedule and earlier in the day. The committee acknowledges that if MATH 050 and 110 continue to be taught by part-time faculty this recommendation will present scheduling issues.

4 Academic Support

In addition to the above proposed changes to occur within the department, the committee believes the academic support structure in place for remedial mathematics courses also requires some modifications.

- Tutor Lab and Times: Most universities employ a different tutoring lab model than Clarion. They have a dedicated space set aside that is staffed with tutors throughout the day. Students can simply walk in for help during any of the hours of operation, but they can also set up a regular meeting schedule in the room with a tutor they like. This removes some of the distractions facing students in our current structure who tend to meet in more social settings. It also allows for more flexibility. In the current system, students who cancel a meeting with their tutor must either negotiate another meeting time or simply wait until their next scheduled meeting (which might be a week away). With a tutoring lab they could stop by and work with a different tutor once their schedule opens up again. If scheduling is done carefully, this new model should not add much more work for the tutoring coordinator nor expense to the current tutoring budget. The committee has more specific suggestions that they would be happy to share with the coordinator if the proposed changes are accepted.

- Tutor Vetting and Education: It would be desirable for the mathematics department to have more oversight of mathematics tutoring for MATH 050 and 110 students. Our current process for finding reliable tutors for remedial mathematics seems to be very ad-hoc. The committee suggests that the opinions of mathematics faculty be weighted more heavily when deciding to hire tutors.

- Advising: The committee believes that academic advisors need to be better educated on the expectations of and opportunities provided to students placed into mathematics remediation. Perhaps the university and/or the committee could run a workshop for department chairs after any proposed changes are accepted.

- Study Skills and Time Management: The committee has evidence that many students who fail MATH 050 or 110 simply are not "college ready". It is not the mathematics holding them down, but rather the expectations and responsibility of being a college student. The committee, along with documented evidence [6], believes that the university should mandate some sort of service for all students who place into these remedial courses that helps to acclimate them to college life. Possibilities include student mentor, workshops, activities, etc.

5 Conclusions

In summary, the Committee on Developmental Mathematics, with full support of the Department of Chemistry, Mathematics, and Physics, proposes the following changes to mathematics placement and remediation:

1. Switch to the ALEKS mathematics placement system with some sort of pilot program for students entering Fall 2017 through Fall 2018 in combination with our current placement model. Review the effectiveness of the pilot before committing to full implementation for students entering Fall 2019.
2. Rewrite the MATH 050 curriculum as discussed in this proposal with possible pilot course(s) or implementation starting Fall 2017 with full implementation by Fall 2018.
3. Perform minor alterations to MATH 110 curriculum for Fall 2017 or Spring 2018 implementation.
4. Formalize proposed changes to mathematics tutoring and tutor vetting process during 2016/2017 school year with action to begin Summer 2017.
5. Hold a workshop for department chairs and/or representatives to explain changes before orientation for Fall 2017 incoming class begins.

References

[1] *Aleks*, https://www.aleks.com/, accessed June 2016.

[2] Tobey, John and Jeffrey Slater, *Beginning Algebra*, Pearson, 2012.

[3] Tobey, John and Jeffrey Slater, *Intermediate Algebra*, Pearson, 2012.

[4] Charles A. Dana Center and Complete College America, Inc. and Education Commission of the States and Jobs for the Future, *Core Principles for Transforming Remedial Education: A Joint Statement*, 2012.

[5] Elizabeth Zachry Rutschow and Emily Schneider, *Unlocking the Gate: What We Know About Improving Developmental Education*, MDRC, 2011.

[6] Complete College America, *Remediation: Higher Education's Bridge to Nowher*, 2011.

Tables

Table 1

Remedial Course Grade vs. Math SAT Score

MATH050 Grade	**Ave. Math SAT**		**MATH110 Grade**	**Ave. Math SAT**
A	409.8		A	463.1
B	388.7		B	448.8
C	374.3		C	436.6
D	363.3		D	428.9
F	366.5		F	429.2
W	374.1		W	425.4

Table 2

MATH 050 Letter Grade vs. Letter Grade in First Subsequent Mathematics Course

MATH050 Grade:	**A**	**B**	**C**	**D***	**F***
A in Next MATH Class	31%	14%	4%	3%	0%
B in Next MATH Class	38%	28%	14%	14%	8%
C in Next MATH Class	12%	25%	32%	22%	25%
D in Next MATH Class	10%	17%	24%	28%	15%
F in Next MATH Class	7%	11%	15%	25%	36%
W in Next MATH Class	0%	2%	1%	6%	5%

*Most students receiving a D or F in MATH050 would be repeating the course for their subsequent grade.