USING TECHNOLOGY TO CREATE DEGREE SPECIFIC MATHEMATICS COURSES

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With the dynamic changes in the rapid development of technology, education must revolutionize itself to return to the forefront of innovation by training independent, creative thinking students, and constantly updating and implementing technological advancements into the classroom. The most prominent influence of technology in education is the massive amounts of colleges/universities offering online course. Online courses have become the new standard of education for millions of students, and incorporating applied mathematics problems into curriculum have never been easier via the technology online courses employ. Moreover there are numerous benefits to both students and instructors, and these benefits increase as online courses integrate additional technological developments. Most importantly, the actual implementation process using technology is painless, quick, and easily adjusted for each educational institution's unique needs. Thus mathematics courses designed for each major will be a reality, and we as educators must begin the groundwork now.

A quick scan of recent literature provides a strong case on why teaching mathematics that directly incorporates individual majors proves to be successful: Students have less math anxiety, students demonstrate higher mathematical retention, and students develop deeper analytical abilities (Garofalo, 2000; Thilmany, 2009; Zajacova, Anna, Lynch, Scott M., Espenshade, Thomas J., 2005).

Recent advances in neuroscience have encouraged extensive research on math anxiety. Ian M. Lyons and Sian L. Beilock published impressive findings in 2012 that support degree specific mathematics courses. In their studies, Lyons and Beilock focused on those individuals with high levels of mathematics anxiety (HMAs). HMAs display the typical characteristics of anxiety such as fear, apprehension, and physical symptoms such as tension. Not surprising, HMAs math performance is lower than that of their low math-anxious (LMA) counter parts. To determine what, if any, brain reactions differences between HMAs and LMAs, Lyons and Beilock conducted several experiments.

Twenty-eight participants were chosen based on their answers to 25 questions that asked candidates to rate their anxiety associated with given mathematical situations. Fourteen HMAs and 14 LMAs were chosen based on their responses to the 25 situations such as going to a math class, and receiving and/or buying mathematics textbooks.

Next these twenty-eight participants were given a general anxiety trait questionnaire. This questionnaire addressed traits displayed when math anxiety was felt, such as feeling anxious and sweating.

After the initial preliminary questionnaires we see the most resounding results: Actual physical tasks were measured using Functional Magnetic Resonance Imaging (fMRI). MRIs use a magnetic field and radio frequency pulses to create a computer-based image of almost any internal body structure. MRI does not employ ionizing radiation rays as in x-rays. fMRI is the process by which MRIs are used to measure metabolic changes in the brain (fMRI, 2011). Taking full advantage of fMRIs, Lyons and Beilock findings confirmed what mathematics teachers have been observing for decades: Math Anxiety is REAL.

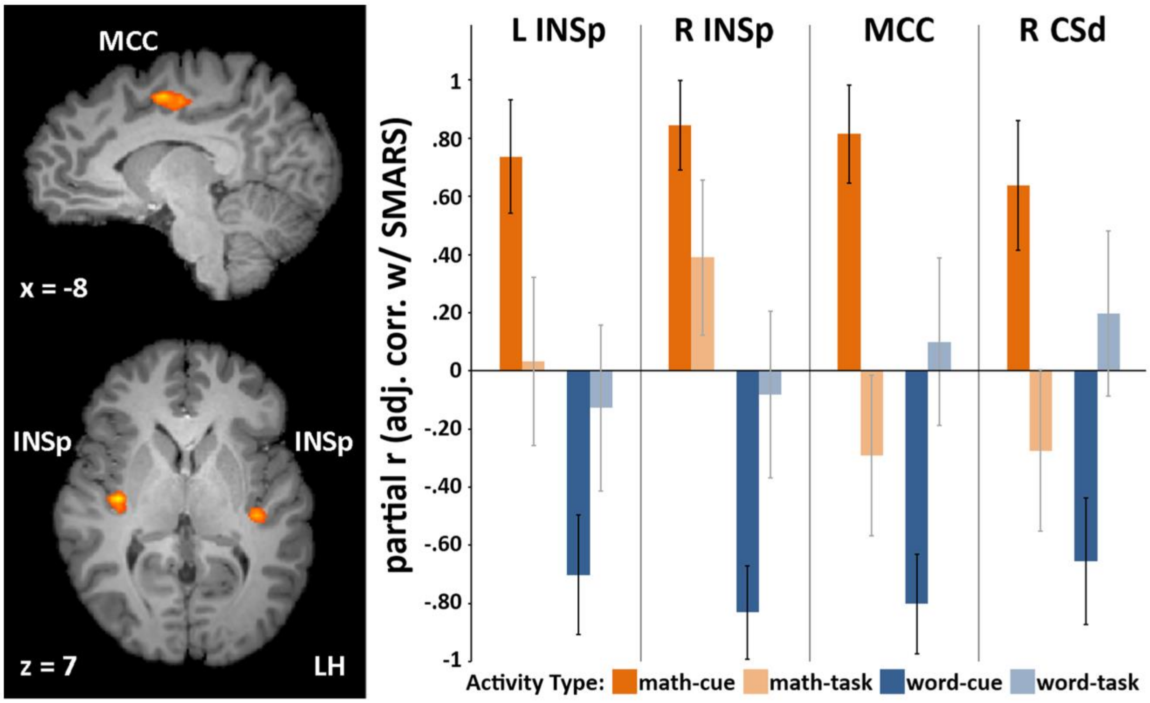

Figure 1 Retrieved from http://www.plosone.org/article/info:doi/10.1371/journal.pone.0048076 April 20, 2013

Figure 1 shoes the levels of L INSp, R INSp, MCC, and R CSd for four separate activities. The most important aspect to note is the INSp, left dorso-posterior insula, results. INSp activity is associated with bodily threat activity and that of instinctual pain cues. Note on the Figure 1 that Math-Cue had a far greater affect than a math task. Moreover, given that math-tasks and word-cues/tasks have a weak statistical difference, there is a great deal of evidence here and in the remainder of Lyons and Beilock's study to suggest math anxiety must be dealt with before a student physically manifests anything mathematical!

My own personal research in the classroom, as any mathematics educator will validate, supports the results of Lyons and Beilock. Teaching online, I am able to review all my students' comments as they are written on Blackboard, in emails, blogs, and recorded via ERAU Worldwide EagleVision technology. Before the academic semester begins, students introduce themselves via Blackboard. Roughly 50% of my students, from remedial mathematics to calculus include a statement about fearing mathematics. Here are some direct samples:

"I hope we all make it through this with our sanity! LOL."

"Math is very interesting to me but my skills have eroded over the years"

"I hope I can keep up and learn the material"

"I was becoming okay at math but had to take a break"

"Hope this class is easier than it looks!"

The samples above are from one single class, and all of which were directly sent to me, their instructor (versus peer-to-peer comments). Furthermore, as you can infer from the sample comments, the course had not even commenced yet.

Along with anxiety in mathematics courses comes decreased comprehension. This can also been inferred from Lyons and Beilock's research as they explicitly stated that HMAs typically were underperformers in mathematics subjects. Ashcraft and Krause further the strong correlation between math anxiety and performance by including working memory into their research (2007). Working memory is diminished by math anxiety, and thus why HMAs perform so poorly on mathematics tests. Moreover, similar to Lyons and Beilock, Ashcraft and Krause's experiments supported that students do not suffer from the draining effects of math anxiety until a mathematical task (computational task) is introduced.

Ashcraft and Krause share an interesting opinion in their paper: "Furthermore, math must be taught in school, unlike language, which children learn naturally from their surroundings early in life," (2007). I value this statement, but wholeheartedly disagree; math is and should be taught at an early age from children's natural surroundings.

Upon writing this paragraph, I headed off to my local supermarket to stock-up on some bulk foods such as nuts, oats, and dried fruits/vegetables for my trip. As I was scooping the raw cashews out of the container, I overheard a mother explaining weight and fractions to her two children, who were three and five. They were scooping out peanuts, and the mom was explaining how to weigh the nuts and compute cost. I interrupted her, describing the paper I was writing, and how I was so impressed with her teaching mathematics to her children at a young age. To my surprise, her parents owned a bakery, and she was taught fractions, measurements, and food preparation at a very early age. She also described how her mother would explain fractions to her, just as she now does to her own children.

Given this amazing, and timely experience, among my own personal experience, the statement made by Ashcraft and Krause may perhaps ignite mathematics anxiety, and a large misconception among people about mathematics. There is a great deal more mathematics being taught at a young age and this is the precise reason I create learning centers for children up to five years of age (see www.imaginationchildexploration.com).

Clearly developing mathematics courses to support and enhance degree programs has a great deal of advantages over developing mathematics courses first and then requiring them for specific degrees. Now we will examine how to begin this much needed implementation naturally.

Using Embry-Riddle Aeronautical University Worldwide (ERAU WW) as a case study, we will examine techniques that can be utilized at ANY Higher Educational Institution (and actually any level of schooling). ERAU WW is literally worldwide: There is a combination of campus teaching and online teaching, which campuses spanning five continents. The online portion of ERAU WW's courses utilizes Blackboard and Saba Centra web conferencing technology, known as EagleVision at ERAU WW.

For the most natural and logical creation of mathematics courses for specific degrees, Blackboard is a great medium to utilize. Blackboard houses all online courses at ERAU WW, providing a central location for all content, some tests and quizzes, wiki's, blogs, discussion boards, grades, instructor information, and other information necessary for the development of a course. Most mathematics tests and assignments are in Pearson's MyMathLab. MyMathLab allows great flexibility when creating assignments, as MyMathLab offers a large bank of pre-made questions, enables instructors to creating their own questions, and differentiates between homework, tests, and quizzes. MyMathLab also allows students to access a digital copy of the textbook, and provides assistance for students when they are struggling with homework. Moreover, instructors can create personalized study plans for each student, and these study plans are automatically updated by MyMathLab as the student masters a given skill.

Given the demand of accrediting institutions and the great amount of emphasis placed on these accreditations, the creative development of a college/university is often unintentionally sacrificed, especially in our dynamic age of technology, in order to meet strict accreditation requirements. Since it is impossible to instantaneously change the complicated accreditation process and still ensure colleges/universities are adequately educating their student bodies {this is a wonderful opportunity for all Institutional Research Professionals}, innovative approaches must be implemented to develop mathematics courses for specific majors, using mediums readily available. This is where Blackboard and MyMathLab assume a leading role in the development of degree specific mathematics courses.

Blackboard is a course developer's best friend as it houses a multitude of tools in one location, which is easy to navigate. Blackboard allows professors to take advantage of discussion boards that welcome creativity. ERAU WW mathematics courses use these discussion boards in various roles, while still exceeding all established learning outcomes necessary for accreditation. Each week, in addition to the traditional mathematics coursework, students are assigned a discussion board problem that demonstrates how the current mathematical topic is relative in aeronautics. For example, in calculus courses students are assigned discussion board problems that investigate atmospheric conditions, zero gravity, and derivatives in relation to the landing path of an aircraft. In trigonometry students explore the landing paths of aircrafts, the mechanics behind GPS systems, and the importance of trigonometric functions in aircraft design. Currently ERAU WW is redeveloping the basic mathematics course to incorporate portions of a graduate level aeronautics research problem:

GNED 103 Basic Mathematics. GNED 103 is the general educational requirement course for mathematics. The online course is four weeks long, comprised of four modules with the following descriptions:

1. In this module, you will learn how to perform the basic operations of addition, subtraction, multiplication, and division using integers. Exponents, square root, order of operations, and solving equations will also be introduced. Operations with mathematical expressions are also included. Moreover, the student will also learn how to apply the concepts to problem solving.
2. In this module, you will learn to use the addition and multiplication principles to solve linear equations. Word sentences will be translated into equations that can then be solved. You will also review arithmetic operations with fractions and simple rational expressions. The concepts will also be applied to problem solving.
3. This module presents more applications involving decimals and linear equations. Ratio, proportion, and percent are valuable tools in some of the non-math courses in the degree programs. You should be able to apply those tools to problem solving and that is one of the reasons they are included in this short course. Note that the textbook sections on computation with decimals are omitted. You are expected to use the calculator for computations involving decimals.

You will use MML to review all the material covered in the previous modules. The review assignment does not count as part of the MML assignment grade. The review is provided to help you solidify the concepts and skills presented in modules 1 – 3. You are strongly encouraged to complete the entire review before attempting the final exam. The final exam is a two-part exam. It is an open book exam designed to be completed in approximately a total of four hours; two hours for each part. It is comprehensive in nature and includes problems representative of most of the assigned sections in the textbook.

Blackboard discussion boards are a perfect medium to implement mathematics problems that are application based while meeting all accreditation standards required by accreditation institutions. More importantly, discussion boards give students the opportunity to explain the analytical thought process in the *spoken language* versus the standard mathematical expressions that often leave students confused. Reviewing students' discussion board comments clearly demonstrate the strategic value of discussion boards as a method for increased mathematical comprehension:

"Thanks, I sometimes get so bogged down with the details I can't see what's right in front of me anymore. Here's my second attempt. Fingers crossed..."

"Number 1 looks good by my calculations. Good work. And if you need it in the future, the approximate sign in mathtype is in the button in the top left corner along with greater than or equal to signs. I didn't have a problem using my imagination though."

"Daniel, great job on problem #2. It helped me catch an error that I made on mine. Thanks!"

"When I started thinking about this assignment I was wondering why we needed to write about triangles, and reading your discussion helped me to have more of an open mind about the triangle. It is amazing how the minds in the past were able to come up with accurate formulas and measurements that are still used today. Great post!"

"Excellent point about how the triangles enable the architects to design a bridge to support whatever the function its being built for. There is a bridge in southern Germany southeast of Stuttgart that I used to fly under on a regular basis when I was stationed there. It is a beautiful suspension bridge. I am very glad they know what they are doing in building them. Good pictures detailing the stress and support the triangles provide."

"I have absolutely no sense of direction, and about a year ago I finally got a phone with GPS capability. I have no idea how I lived so long without it! Interesting point about how the military helped introduce this technology."

"Great post. I did not realize there were so many satellites working to provide positioning information. I use GPS on a regular basis now, and could not imagine life without it."

These few samples of discussion board comments barely demonstrate the camaraderie formed and the deep insights gained within these discussion boards. The discussion boards are my favorite part of the course as I use them as a leaping point to enhance the discussion and in-depth comprehension mathematics in their daily lives.

Pearson's MyMathLab offers a plethora of opportunities to increase the applicable content in any mathematics course. All homework problems in MyMathLab can be edited to suit instructor's unique needs. Furthermore, the instructor can create new problems and add them to MyMathLab's already existing problem set.

Pearson's MyMathLab has an even greater potential that will empower math instructors to create mathematics courses that fully support majors within their colleges/universities: Online, Customizable Textbooks.

One of the immediate benefits of customizable textbooks is that schools can print only the portion of a given textbook that is needed. This saves students money while allowing instructors to create a textbook that fully supports their learning outcomes without burdening students with unneeded information. Moreover students can purchase online versions of these books, saving even more money and our environment.

The next step for Pearson is to create a medium that allows mathematics instructors and current textbook writers across the globe to become authors and coauthors of customizable online textbooks designed specifically to support given degree programs.

There are several key components to this design. Authors and professors can make their degree specific math problems and course work, to include self-developed textbooks, available for use by other instructors and schools. This will eliminate duplicate work, allowing professors to build degree specific courses from already available problems, textbook chapters, and complete textbooks. Pearson can compensate professors through a percentage of the custom textbooks sales based on how much a given author's/professor's material is utilized. Or Pearson can establish a developer's website where instructors can search for specific applied problems and add problems to their textbook cart similar to shopping at Amazon.com, Ebay.com, etc. There are unlimited possibilities here, all of which benefit Pearson and innovative mathematics instructors.

Given the strict learning outcomes of accredited colleges/universities and the lengthy time it takes to modify approved learning outcomes, custom textbooks can be initially be implemented as supplementary material. Given these books will be available, if not solely available, in electronic format, the will be cheap and easily accessible for students. Furthermore, having the Pearson MyMathLab platform accompanying the textbooks allows students to maintain the same platform they are currently using with their classroom textbook (assuming the course is an online course). Homework and test problems can easily be incorporated from these supplemental books into the course's textbook test bank. Ultimately the success of these supplemental textbooks will allow them to become the new standard in colleges and universities. This will enable education professionals to quickly adapt class material to meet the educational needs

Technology offers colleges and universities a great deal of flexibility in course development when used properly. The next step for institutes of higher learning is to develop the Class App (Garten, 2013). The Class App will replace current online courses by integrating all the features of Blackboard, MyMathLab, textbooks, supplemental tutoring, note taking capabilities and much more into a single App built for tablets. The Class App allows for one-stop shopping for students, and saves headaches for instructors as everything for the course is included in a single App. The ability to quickly modify Apps from swapping out textbooks to a dynamic curriculum change is fairly easy, and will continue to become more user friendly as technology continues to progress. Having a course that functions as an App will decrease late/missed assignments as students can complete assignments virtually anywhere. The note taking capability will allow students to quickly save test scratch work and email to the professor for partial credit.

The Class App will empower college and students, yet as with all technology, will quickly become outdated. Where do we go from here? I say to infinity beyond. Education is lagging behind technological developments, but is making great strides to catch-up, and with the proper leadership will once again be at the forefront of society's advancements. The resistance to change educational standards and learning outcomes is fear based, and no different than a student suffering from math anxiety. I predict successful educators of the future will assume three primary roles: Educator, Business Leader, and Psychologist as all three factors are vital in reforming education to meet the needs of our dynamic world. In the interim we must forge ahead integrating applications of mathematics into all degree programs to enhance students' analytical thinking skills, a vital component of the amazing future awaiting us.

References

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. Psychonomic Bulletin & Review (Pre-2011), 14(2), 243-8.

Functional MR Imaging (fMRI, 2011) - Brain, American College of Radiology & Radiological Society of North America, retrieved December 30, 2011

Garofalo, J., Drier, H., Harper, S., Timmerman, M.A., & Shockey, T. (2000). Promoting appropriate uses of technology in mathematics teacher preparation. *Contemporary Issues in Technology and Teacher Education* [Online serial], *1* (1).

Garten, H. (ICTCM Proceedings, 2013). The Class App.

Lyons IM, Beilock SL (2012) When Math Hurts: Math Anxiety Predicts Pain Network Activation in Anticipation of Doing Math. PLoS ONE 7(10): e48076. doi:10.1371/journal.pone.004807

Thilmany, J. (2009). Math anxiety. Mechanical Engineering, 131(6), 11-11.

Zajacova, Anna, Lynch, Scott M., Espenshade, Thomas J. (2005). Self-Efficacy, Stress, and Academic Success in College. *Research in Higher Education*, 46:6, 677-706.