SECTION A

Igniting Aeronautics into the Embry-Riddle Aeronautical University Worldwide Mathematics Curriculum

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ABSTRACT

Mathematics is the backbone of developing critical and analytical thinking skills. As society evolves and technology develops at an unseen pace, educational institutions must guide students to becoming autonomous thinkers with the ability to apply and invoke learned knowledge. Embry-Riddle Aeronautical University Worldwide students are united under their mission of aeronautics, and thus Embry-Riddle Aeronautical University Worldwide courses must enhance and support this mission. This paper explores the benefits and methodology of redesigning the online version of both MATH 142 and GNED 103 to successfully implement research based learning, the Bollinger/Rosado Teaching and Learning Effectiveness Symposium 2012 Theme, and demonstrate the ease in extending research based learning to all Embry-Riddle Aeronautical University Worldwide online mathematics courses.

Why Incorporate Research into Mathematics Education

Embry-Riddle Aeronautical University Worldwide has set precedence with its superior online education curriculum, and must continue the trend of cutting-edge excellence. Even in its infancy, online education stemming from the rapid advancement in technology is impacting education in astonishing ways, demanding a more flexible, innovative curriculum. Embry-Riddle Aeronautical University's Quality Enhancement Plan (QEP) continues the advancement of Embry-Riddle Aeronautical University Worldwide's educational excellence by emphasizing the need for undergraduate research spanning all curriculums, to include innovative cross-curriculum research.

Focusing on the mathematics curriculum, the benefits of implementing research based learning have tremendous advantages that exceed the prominent standards established in the QEP. First, a large amount of educational literature supports that fact that teaching mathematics by using research based methods is an extremely successful methodology leading to positive outcomes. Second, teaching mathematics using a cross-curriculum approach (in the case of Embry-Riddle Aeronautical University Worldwide using aeronautical-based subjects), reduces the level of math anxiety experienced by students. Third, implementing research methods fosters the use of technology, providing students with another much needed skillset. Finally, due to the current structure of Embry-Riddle Aeronautical University Worldwide online mathematics courses, the implementation of research-based learning can seamlessly be introduced while surpassing current learning objectives.

Ignite. The Embry-Riddle Aeronautical University Quality Enhancement Plan (QEP) 2012-2017 (Ignite) highlights the value of research as an interdisciplinary methodology of advancing knowledge through the development of innovative solutions to dynamic problems.

Moreover, the executive summary of Ignite continues to explain how research promotes growth at all levels: Social, Intellectual, Personal, Professional, and Academic. With the rapid increase in information and the dynamical characteristics governing the world today, it is imperative for the mission of Embry-Riddle Aeronautical University to focus on developing an enriching learning environment that fosters the growth of intellectually dynamic individuals. The methodology for achieving this goal is simple: Research based learning in the mathematics classroom.

Successfully Teaching Mathematics via Research Based Learning. The subject of mathematics is well-versed in research based learning methods, the most famous being The Moore Method. The Moore Method, named after its founder R.L. Moore, is implemented in institutions of higher learning across the globe. The Moore Method focuses on the role of the student, to learn, and views the instructor as a guide versus a lecturer. W.S. Mahavier has implemented The Moore Method for over thirty years, guiding students to learning mathematics versus employing the typical classroom mathematical lecture. Giving students just a few theorems to start, Mahavier's teaching style (or lack thereof) encourages students to uncover mathematics for themselves, advancing only after the students have proven the necessary theorems. Textbooks need not apply to classes using the Moore Method as all learning is self-guided research (Mahavier, 1999).

The Moore Method promotes inquiry based learning and collaborative learning (Mahavier, 1999), two very important properties of Ignite. Depending on students' abilities, several steps can be taken to adapt the course material to the student: Larger theorems can be deconstructed into smaller theorems, hypothesis can be less restrictive, and, most importantly, the professor is there to guide the students at all times (Mahavier, 1999). The Moore method has

been shown to encourage students to become confident, inquisitive intellects in any field studied (Renz, 1999). Given the extensive literature, research, and conferences held in honor of R.L. Moore, it is clear why R.L. Moore and his methods produced hundreds of stellar mathematicians and scientists for almost 100 years.

Mathematics research based learning has proven successful far beyond The Moore Method in the advanced Mathematics classroom. An extensive report by Peter Sullivan, published by the Australian Council for Educational Research (ACER) in 2011, emphasized the need for mathematics to prepare students not only for mathematics majors, but for successful careers in general. This extensive document discussed a very important issue of how students do not apply the mathematics learned in school to their daily lives, such as simply situations of shopping and weight loss. When observed on the job, subjects often used intuition to solve problems versus ratio and proportion techniques taught in school. Sullivan reasoned that mathematics must be taught in a multidiscipline based context, and the pedagogy used must encourage the use of mathematics outside the classroom. The goal is to enable students to implement the mathematics learned in their own lives versus keeping the learned methodologies confined to the classroom.

Over twenty years ago Lynn Arthur Steen from St. Olaf College urged teachers to realize the need for mathematics education to transform and meet the demands of society. Steen stated, "Today's students will live and work in the twenty-first century, in an era dominated by computers, by world-wide communication, and by a global economy. Jobs that contribute to this economy will require workers who are prepared to absorb new ideas, to perceive patterns, and to solve unconventional problems," (1989). Furthermore Steen's declaration reemphasizes that mathematics is more than just a subject of numbers, but a subject that helps students think clearly

(Steen, 1989). The National Security Agency, the self-proclaimed largest employer of Mathematicians (all U.S. Citizens), hires mathematicians for their ability to think, analyze, and solve difficult problems with innovative ideas and resources (http://www.nsa.gov/research/tech_transfer/advanced_math/index.shtml, Retrieved on June 26, 2012). Mathematical research based learning plays a vital role in priming students to reason at levels far deeper than currently experienced.

Learning mathematics through research becomes even more valuable when the research pertains to the students' interests, to include college major, career position, and general inclinations of the students. Besides the sheer academic advantage with correlating mathematics with a student's given major, the correlation subdues a large hurdle faced by mathematics teachers of all levels: Math Anxiety.

Math Anxiety. Students who recognize mathematics as part of their academic majors have less math anxiety than those students who perceive mathematics as disjoint from their majors. Math anxiety, as with anxieties in general, can assume many forms, such as nervousness, tension, mental-blocks, and physical illness. Researchers in Spain hypothesized that math anxiety influenced students when selecting majors, suggesting those with higher math anxiety chose less technical majors compared to their technical major counterparts. Surveying students in 23 different majors, the researchers found that students with technical majors had less math anxiety than their less-technical counterparts, such as health science majors (Thilmany, 2009).

Ashcraft and Krause (2007) research supports Thilmany's findings, and expands beyond the psychometric discussion by analyzing the cognitive effects of math anxiety. High math anxiety requires the allocation of attention and mental resources that would otherwise be used to solve the math problems at hand. Since mathematics involves a high-level of cognitive thought

versus simple memorization, this becomes extremely detrimental in successfully completing mathematics courses. Mathematics, as compared to the English language, relies on highly abstract symbols and thus demand more working memory than learning grammar associated with the English language.

Expanding on the detrimental effects of stress given by Thilmany (2009) and Ashcraft et al. (2007), Zajacova, et al. (2005) research suggests a strong correlation between self-efficacy and stress. Self-efficacy determines whether a student determines a task to be stressful suggesting a negative correlation between self-efficacy and stress (Zajacova, Lynch, and Espenshade, 2005). This can be damaging to a student's aeronautical career and even hinder the student from progressing in his/her academic work.

Rapid Technological Advancements. The rapid influx of information available to students at every moment of everyday easily compounds any anxiety, especially when coupled with learning mathematics. There are two types of anxiety associated with technology: Learning technology, which is similar to mathematical anxiety, and Disconnectivity Anxiety, which is where a person feels uneasy, anxious, and/or depressed for a period of time due to lack of internet connection, FaceBook access, etc. (Taylor, 2009). This powerful statement begs to question why traditional educational techniques are utilized in today's dynamic environment that fosters instant gratification and connectivity.

Mathematics is a perfect medium to implement technology in a supplementary manner as technological advancements promote learning mathematics through research and exploratory learning, and minimize Disconnectivity Anxiety. Garofalo, J., Drier, H., Harper, S., Timmerman, M.A., & Shockey (2000) give an array of examples on implementing technology in the mathematics classroom. The authors stress the importance of learning with technology

versus learning about the technology itself, in addition to ensuring the technology is introduced in context and connects relevant topics (Garofalo et al., 2000). Technology in the mathematics classroom enhances the mathematics curriculum through increased understanding and comprehension in addition to honing analytical skills necessary to implement the technology.

Redesigning Mathematics Courses

Mathematics is a beautiful subject, often an overlooked art-form, that when implemented properly can accelerate Embry-Riddle Aeronautical University to the forefront of educational development. The preceding background information provides a strong case on why teaching mathematics using research based techniques in addition to incorporating students' interests (aeronautics) is highly beneficial: Less math anxiety, more interest in learning mathematics and technology, and a greater sense of accomplishment and enjoyment. Moreover, incorporating mathematical research supports Embry-Riddle Aeronautical University's QEP, Ignite.

Embry-Riddle Aeronautical University Worldwide Online Mathematics courses have already begun to implement a structure conducive to research-based learning: Discussion board assignments. Through an extensive analysis of the current MATH 142 online structure, this paper redesigns MATH 142 to meet the laudable Ignite standards and exceed current learning outcomes. Applying the methodology used in restructuring 42, GNED 103 is restructured by utilizing a project from Embry-Riddle Aeronautical University Worldwide Master's Program.

Case Example 1: MATH 142 Trigonometry. Simply performing exercises from the textbook is not sufficient in demonstrating how Trigonometry relates to aeronautics, as only one or two exercises contained some content related to aeronautics. This lack is quickly overcome within the discussion board, where students were asked to research and/or explore a given concept and how it related to the mathematics at hand. The comments below, taken from the

discussion board of MATH 142 April 2012 (www.erau.blackboard.edu), clearly support the case at hand. These comments demonstrate enthusiasm for the mathematics, students proudly going beyond the required work, and appreciated humor that sparked additional intellectual discussion:

> "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."
>
> "Here is the latest endevor. First two pages are required and i highly recommend a review of page three. It has a link to an awesome Youtube video. Since we are stuck on studying French folks, Au revoir."
>
> "Enjoyable/knowledgeable post. I can definitely relate to the "change of types of patterns we look for in nature" on a personal level. Even driving by a shrub, I can't help but to think of how fractal geometry can be applied to it. Also, the implications fractals have in data compression is amazing to say the least. "I just thought it was a bigger and better camera" doesn't really fly here anymore. Arthur C. Clarke does a excellent job at opening up our eyes to the bigger picture in this subject."

Clearly the students valued the discussion board assignments, as they were able to add their own expertise on how they, often unknowingly, used mathematics every day. The math anxiety seen in the homework assignments became obsolete within the discussion board, and led to a 360^{o} (or 2π) attitude shift. The fervor and creativity of the discussion board far surpasses the preceding discussion board samples. This unleashed ingenuity made it clear that students were capable of amazing mathematical feats when their focus was on applications versus rote problem solving.

Clearly research based projects that support learning mathematics, promote analytical and technological development of the student, and advance the mission of Embry-Riddle Aeronautical University Worldwide can easily be implemented and welcomed into most online mathematics courses through redevelopment of the discussion board exercises. The first case example is MATH 142. Currently, the MATH 142 discussion-board assignments are:

1. In this first module item, you will introduce yourselves to your instructor and fellow classmates. You should post your introduction no later than Day 5 of the module. Please refer to the Discussion Board Quick Start Guide for assistance in posting, replying, and adding attachments in the Discussion Board forum. Compile a brief biography and post it to the M1.3 - Introduce Yourself discussion forum. Include in your biography information such as where you live, the type of work you do, what are your professional and educational objectives. Tell us something you would like us to know about you and then tell us something that would surprise us. Do this by Day 5. Read the posts from your peers and get to know the people with whom you will be discussing the math problems and solutions during the term. Comment or strike up a conversation with at least three members of the class. This discussion is not graded, but it will be a good idea to become accustomed to posting your work by Day 5 and

responses to your peers by Day 7. There will be no extensions beyond Day 7—no exceptions. In graded discussion, late posts will not increase your score. For important details on graded discussions, see the MATH 142 Discussion Board Rubric in the Resources area.

2. Your task for this discussion activity is to research and write a summary about some historical, important, or practical aspect of triangles. Your summary can be entertaining, but should cover something non-trivial, like where are triangles in use and how do we use them? Your contribution must be instructive to the class.
3. Show all your work when solving the following problems: Exercise Set 5.2, Practice Exercises, problems 27 and 69 (pp. 510-511). Exercise Set 5.2, Application Exercises, problem 79 (p. 511). Use Graphmatica or a web applet to graph each function and then copy-and-paste the images to your assignment for the following problem: Exercise Set 5.5, Practice Exercises, problems 19, 30, and 59 (p. 554). Show all your work when solving the following problems: Exercise Set 5.7, Practice Exercises, problems 46 and 69 (p. 584) {Note: These problems resemble the students' homework problems for these sections}.
4. Show all your work when solving the following problems: Exercise Set 6.3, Practice Exercises, problems 7 and 19 (pp. 634-635), Exercise Set 6.5, Practice Exercises, problems 11 and 41 (p. 656), Exercise Set 7.1, Practice Exercises, problem 1 (p. 670) {Note: These problems resemble the students' homework problems for these sections}.
5. View both videos below. The first, Fractals: The Colors of Infinity is a 52-minute FMG video. You can watch it in its entirety or view it in segments. Segments 1-3

should probably be viewed all at one time, these segments describe the essentials of the Mandelbrot set. Implications of this discovery will be in segments 4-14. The list of segments is on the right side of the web page. As you view the FMG video, take notes about your thoughts on the famous set and its implications. Your notes will help later when you write your summary.

6. Create an initial submission in Microsoft Word, using your equation editor and graphing tool to post interesting variations on the parametric equations. For each graph you create, identify the specific parametric equations used and the domain for your graph. In a sense, this will be a real art exhibit. Be sure to make a comment on each graph you create as to how one particular graph differs from the other, and perhaps what patterns you observed during your experimentation. Heads-up, be careful about file size. The images could get large, especially if you include color in the graphs' backgrounds. Tradeoffs are part of the issues in this submission (https://erau.blackboard.com, Retrieved on June 23, 2012).

These are excellent mathematical topics but fail to provide the much needed connection to aeronautics, and lack a fluid, continual research experience for the students.

In order to modify this to meet the needs of Ignite, Embry-Riddle Aeronautical University's mission, and the mathematical curriculum learning outcomes, the following assignments can be implemented in place of those above:

1. In this first module item, you will introduce yourselves to your instructor and fellow classmates. Additionally chose an airport of your liking to post with your introduction so your instructor can approve as this airport will be used for projects throughout the course. You should post your introduction no later than Day 5 of the module. Please

refer to the Discussion Board Quick Start Guide for assistance in posting, replying, and adding attachments in the Discussion Board forum. Compile a brief biography and post it to the M1.3 - Introduce Yourself discussion forum. Include in your biography information such as where you live, the type of work you do, what are your professional and educational objectives. Tell us something you would like us to know about you and then tell us something that would surprise us. Do this by Day 5 (Be sure to include the airport you chose!). Read the posts from your peers and get to know the people with whom you will be discussing the math problems and solutions during the term. Comment or strike up a conversation with at least three members of the class. This discussion is not graded, but it will be a good idea to become accustomed to posting your work by Day 5 and responses to your peers by Day 7. There will be no extensions beyond Day 7—no exceptions. In graded discussion, late posts will not increase your score. For important details on graded discussions, see the MATH 142 Discussion Board Rubric in the Resources area.

2. Using your airport from week 1, determine how your airport implements triangles. Yes, this is broad and screaming for creativity. In your work you have studied all types of triangles and now it is time to identify where and how they are used. Look at your entire airport for evidence (the roof and structure are good places to start!). Post a 500-750 word summary along with any relevant pictures emphasizing the mathematics you learned in this module. Be sure to use APA citations as this is what you will use throughout your career at Embry-Riddle Aeronautical University Worldwide, and probably beyond.

3. This week we examine the runways at your airport. First find the following information and provide a write-up using APA style formatting: The number of runways and the length of each. Second, answer the following two questions using the information for one of the runways of your choice, showing all your work using Microsoft Mathematics and embed the work into your document containing the information above: 1. Suppose a plane takes off at an angle of 10^{o} and when the plane reaches the end of the runway it is 500ft off the ground. How far did the plane travel on the runway BEFORE taking off? 2. Suppose the diameter of the plane's tire in question 1 is 40 inches (see http://www.goodyearaviation.com/ for more specifics on aircraft tires). Given your information from part 1, how many revolutions did the tire make before the plane took off? If your plane took off in 10 seconds, what was the tire's linear speed? Angular speed?
4. Welcome to the fourth assignment of your airport exploration. This week we will look at the terminals in your airport. Again, be sure to use APA formatting for the following short answer questions: 1. How many terminals (and/or concourses) does your airport have? What airlines are located in each terminal? What are some of the stores located in each terminal (pay particular attention to those locally-specific stores)? Is there free Wi-Fi? 2. Suppose you are in charge of designing a terminal for a new airport, and the architect presents you with the following diagram:

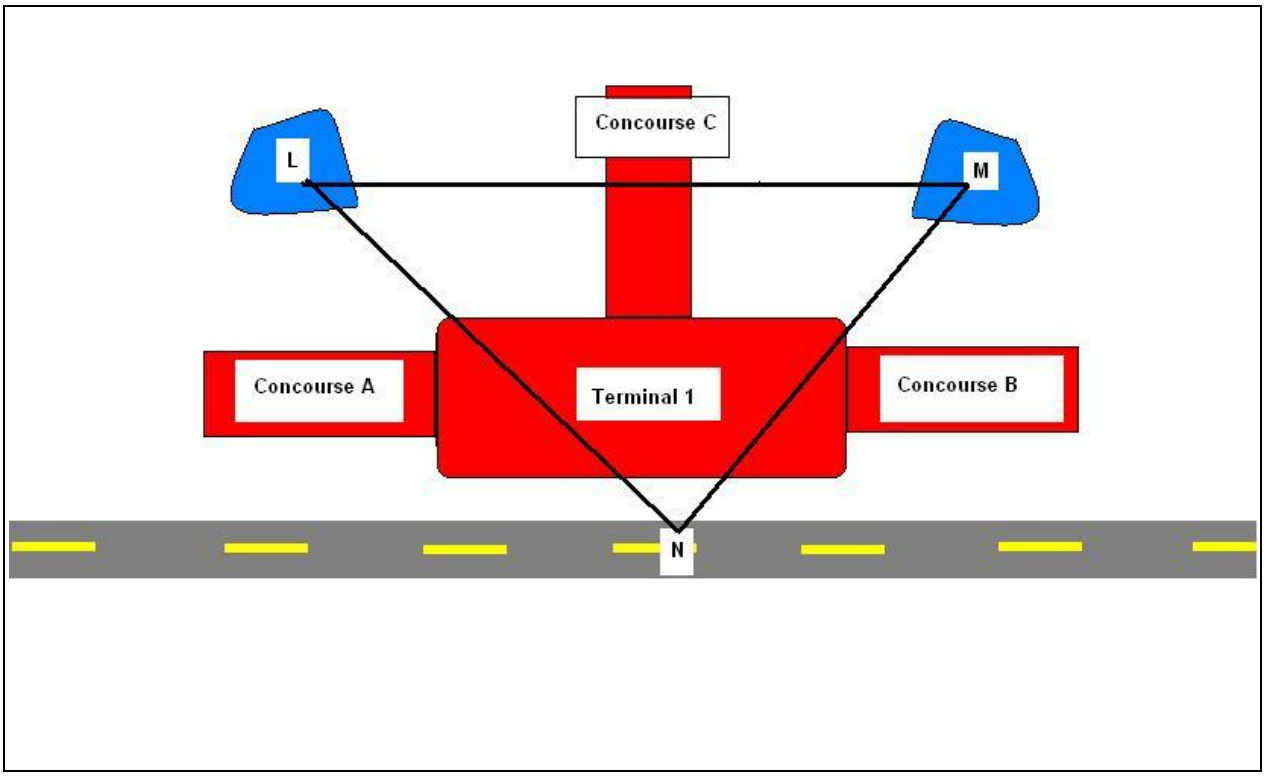

Figure 1. Solving a triangle problem.

In the figure above, the architect is forced to make N a 96^{o} angle versus a 90^{o} angle due to natural environmental restrictions. The distance between the two lakes, L and M, is 9845 feet, and angle M has been measured to be 42^{o}. The architect needs to know all the measurements of the triangle (all angles and side lengths), but the area surrounding lake L is underdevelopment and the architect cannot venture out to obtain measurements. Using what you have learned in this module, find the remaining sides and angles for the architect.

5. View both videos below on Fractals. Then return to your airport and find examples where your airport implements these beauties of nature. For each fractal you find, include pictures (if possible) and a brief summary (location of fractal, why you qualify it as a fractal, etc.). Be sure to use APA formatting and cite all sources.
6. Over the past weeks you have learned a great deal about the airport of your choice and the airports your peers chose to research. One important detail we have not dealt with is the

Transportation Security Administration (TSA). Since September 11, 2001, air travel has dramatically changed with much stress placed on the airlines to uphold customer service and simultaneously ensure passenger safety. Research how TSA's screenings work. Take note of the 'waves' used, and relate this to your current learning objectives with trigonometric functions. You may want to utilize ERAU WW online library.

The new discussion board posts emphasize the same mathematical learning objectives as before while adding a vital research component, broken into smaller components as suggested by The Moore Method. Moreover, each student is required and graded on his/her comments to other students' posts, thus compounding the knowledge the student gains. Requiring APA formatting prepares the student for his/her future career, and allows the student to implement any/all concepts discussed into future research projects and his/her career. Giving the students freedom within this discussion board leads to a great deal of creativity, insight, and humor that is much appreciated, as seen in the comments above.

In addition to student gains, there is no additional requirement of our instructors. Instructors will continue to monitor and grade the discussion board as usual, and the same grading rubric can be implemented. Current instructors should be familiar with APA formatting, and requiring sources cited via APA formatting in discussion boards to avoid plagiarism (as did happen in MATH 142 April 2012).

Thus students are now attaining a much broader skillset through their mathematics course, and an understanding of how mathematics, specifically trigonometry, applies to aeronautics. Math anxieties are subdued with the overarching aeronautical theme, and the ability for students to employ creativity and ingenuity. With little effort additional discussion board topics can be formed (such as focusing on different aircraft, strictly studying airline

safety measures, space exploration, etc.), creating a dynamic learning environment that will ignite students into their education.

Case Example 2: 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.
4. 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 (www.erau.blackboard.com, Retrieved on June 27, 2012).

Within each module students are to work problem sets and post to the discussion board. Each student receives a different problem set as assigned by the instructor at the beginning of the course. Note there are no applications to aeronautics, and most of the course is brute-force mathematics. Furthermore the short duration of the course and self-containment do not foster interaction between student and instructor.

The goal is to Ignite GNED 103 by adapting the curriculum to emphasize Embry-Riddle Aeronautical University Worldwide's aeronautical mission, and thus create a learning environment that fosters the growth of an innovative and analytical thought process for each student. GNED 103 is predominately taken as a remedial course, and most students in the course failed the Embry-Riddle Worldwide mathematics exam, or recognized their mathematics weaknesses and opted to take GNED 103 without even attempting the exam. Therefore the fact that approximately 75% of the students over two sections of GNED 103 expressed their math anxiety through verbal and written communications is not surprising. For all these reasons it is imperative that Embry-Riddle Aeronautical University Worldwide creates an introductory course that establishes an exciting and aeronautically-focused core curriculum, while meeting and exceeding the mathematical learning outcomes.

GNED 103 can easily be transformed into a self-contained, research experience for students that will immediately demonstrate why basic mathematics is vital in aeronautics, and everyday life. A project used in ASCI 602 is easily adapted to the needs of GNED 103 by separating the project into researchable components as suggested by The Moore Method. Below is the original GAVA from ASCI 602:

General Aviation Aircraft Value Analysis (GAVA)

You and 1-5 colleagues are scheduled to make two trips, one a short trip, (approximately 400-800 flight miles), the other a longer trip (800-2,500 flight miles). Assuming the variables listed below, plot two trips for 2-6 colleagues, to determine whether automobile and/or train and/or bus, business aircraft, or commercial transportation is most economical. Specify any assumptions aside from those listed below.

Factors to consider:

Auto: Assume $.55/mile when driving both trips. Each of you will also be driving your personally owned vehicle (POV) from Office to Airport and Airport to Office. When using commercial or business travel, airport parking costs are $3/hour or $20/24 hour period.

Business Aircraft: Assume $1,500.00/hour operating costs.

Personnel: Assume your time costs $100/hour/person up to 9 hours per day for salaried employees. Also, consider whether you can work on a commercial plane (coach), business aircraft, or in an automobile.

Per Diem (daily food expense allotment):$65/day/person

Meeting: 8 hours (plan on a Tuesday 0900-1800)-will you need hotel rooms? If so, factor in $175.00 per person, per night.

Rental car-Required for trips in commercial or business aircraft and by train. Assume $55/day and $35 for half days or less.

Commercial aircraft time:

Assume 30 minutes from Office to Airport, each way; Assume 60 minutes for check-in and security, 30 for boarding, 60 minutes for deplaning and baggage claim, 15 minutes to collect the rental car. Remember, times are per person-what is each colleagues time worth?

En route time: Depends on the route you selected.

Business aircraft time: Assume 30 minutes from Office to Airport; Assume 30 minutes for boarding, 30 minutes for deplaning, 15 minutes to collect rental car. These are per person times. En route time: assume a cruising speed of 300 mph.

Automobile time: Use Google maps (or other online mapping tool) for en route time; based on the trips you select (https://ernie.erau.edu/portal/page/portal/faculty/worldwide/course-guides/files/graduate-cg/asci-602-cg-2012.doc, Retrieved June 29, 2012).

Instead of students working problem sets through disjoint postings to the discussion board, the goal is to encourage interaction between students (similar to MATH 142) and course ownership through the implementation of the GAVA. Below is an example of how the redesigned discussion boards will be implemented:

In this course you will work with your fellow classmates to answer the following question: You and three colleagues are headed on a business trip from ERAU Daytona Beach to ERAU Prescott. Your business trip is for a meeting that begins at 0900 Mountain Time on Tuesday and is completed at 0600 Mountain Time that same day. The mode of transportation is at your discretion, and the goal of the discussion board during this course is to determine which mode is cheapest.

By day two your instructor will place you into a group: Commercial Airline, Private Jet, or Private Vehicle. This will be the mode of transportation you will focus on. Hence it will be important to read the discussion board posts of your classmates and comment on their work as it compares to your findings. Each week the discussion board will be graded according to the following rubric:

GNED 103 Discussion Board Grading Rubric				
85% of your grade comes from your on-time post; 15% results from your responses to your peers' posts				
A	B	C	D	F
Initial post by day 5; follow-up comments by day 7. Solutions to problems clearly demonstrate mastery of concepts and mathematical software used to display results. Well-reasoned arguments with sufficient sources used and documented using APA formatting.	Initial post by day 5; follow-up comments by day 7. Solutions to problems demonstrate understanding of concepts with minor gaps in logic and/or display issues. Sources cited using APA formatting, but could use additional reasoning.	Initial post by day 6 with follow-up comments by day 7. Errors present in arguments but overall idea understood and demonstrated. Display is adequate for understanding. Arguments are weak; additional resources could have been utilized.	Initial post by day 6. Many mathematical errors. Arguments are weak or not present at all.	Initial post after day 7 or missing. Majority of work flawed. Written arguments are incomprehensible.
Dialogue with Peers				
Comments positively challenge peers' findings and encourage additional research, specific questions, comments, and/or additional information posted.	Comments are engaging and relevant to the forum.	Comments are weak and vague or opinionated without authority.	Posed only weak comments such as, "Great Job," and "I agree."	No comments posted.

Figure 2: Grading Rubric for GNED 103 Discussion Board.

Below is data that will assist in the completion of this project:

Auto: Assume $.55/mile. Each of you will also be driving your personally owned vehicle (POV) from Office to Airport and Airport to Office. When using commercial or business travel, airport parking costs are $3/hour or $20/24 hour period.

Business Aircraft: Assume $1,500.00/hour operating costs.

Personnel: Assume your time costs $100/hour/person up to 9 hours per day for salaried employees.

Per Diem (daily food expense allotment): $65/day/person.

Meeting: 8 hours (plan on a Tuesday 0900-1800)-will you need hotel rooms? If so, factor in $175.00 per person, per night.

Rental car-Required for trips in commercial or business aircraft. Assume $55/day and $35 for partial days.

Commercial aircraft: Assume arrival two hours prior to departure, and assume the time from landing to arrival at the meeting location is 1.5 hours.

Business aircraft time: Assume one hour prior to departure arrival time and one hour from touch down to meeting location. En route time: assume a cruising speed of 300 mph.

Automobile time: Use Google maps (or other online mapping tool) for en route time; based on the trips you select

Second, define the corresponding assignments for each week as follows:

1. Given your mode of transportation, find two different options (see below). For each option, explain the cost incurred for the trip, and show all calculations using a mathematics editor of your choosing (Microsoft Excel may be useful here, but you

must show all calculations). Remember to include per diem, gas costs, etc. if necessary. List all costs that you include so your peers know your assumptions (be creative and thorough).

   a. Commercial flights-pick your favorite airline so we have a variety of choices on the discussion board
   b. Car-choose your favorite vehicle for travel as this will
   c. Business Aircraft-see details above

2. This week we want to analyze the different costs you and your peers found last week, and create a formula that, with minor assumptions, will let you predict the cost of travel for you and your colleagues based on the length of the meeting.
   a. Let x be the number of days of travel. For your post in discussion board 1, what was x? {Note x should at least be 1 if you travel in the morning to Prescott and leave at night to return to Daytona Beach. If you stayed overnight, x would be 2. If you drove, x would be significantly larger).
   b. Assume the costs in Discussion Board 1 are fixed costs; that is, no matter how long the meeting extends, you will incur those costs. Define the fixed costs to be b and write down what b equals.
   c. How much does the cost increase by if the meeting extends by an entire day? That is, your travel plans remain the same, and you insert an additional day of hotel, per diem, airport parking (if applicable), rental car cost (if applicable), employee cost, and any additional cost you may have assumed. Be sure to include all details by using Microsoft Mathematics or another mathematical

software that allows you to show all your work and assumptions. Let this value be denoted by the letter m, and this is your variable cost.

d. Since we are learning about solving linear equations, and you have variables x, m, and b, it is time to create our own linear equations to model the cost of the trip depending on the number of days at the meeting. Now, putting your findings from parts a, b, and c together, write a linear equation in the form y=mx+b that models the cost of your trip (y) based on the number of days of the meeting (x). Hence you will have something that looks like: y=$753x + $1344.

e. Using a graphing tool of your choice, graph your line in part d.

f. If your company budgeted $6500 for the trip, what is the maximum duration of the meeting (in days; do not assume a partial day of meeting) so you do not exceed the budget? Be sure to show all work using an equation editor such as Microsoft Equation.

3. This week in your GAVA project we will analyze your prior findings compared to your peers using ratios, proportions, and percents. Be sure to explain all work and use Microsoft Equations editor as needed.

   a. Chose a project from each of the modes of transportation differing from yours (For example, if you researched driving, chose a project focused on commercial aircraft and one on business aircraft). Be sure to document whose project you chose.

   b. What is the ratio of your cost for a single day meeting to the cost of each of the other modes? (You will have two ratios).

c. Take the reciprocal of the ratios above and explain what they mean. Has any information changed?

d. Convert each ratio in part b to a percent. What does this percent mean?

e. Focusing back on your project, what is the percent increase in cost from a meeting that is one day to a meeting that is two days?

4. Welcome to the final week of GNED. Throughout the course we have used the mathematical learning objectives to analyze modes of transportation and their associated cost. In this final post, we will summarize our findings over the past three weeks, and make suggestions on which mode of transportation should be used for a 1 day meeting, 3 day meeting, and a 5 day meeting to achieve maximal company savings (assume you have enough budgeted to support all trip lengths). This final write-up should be approximately two pages long following APA formatting (double-spaced, New Times Roman 12pt. font, etc.). Be sure to include a title and reference page, and properly cite all sources. Additional creative insights are most welcome in this final analysis.

The new discussion board outlined above incorporates more learning objectives through research-based learning, allows and encourages students to invoke creativity, ingenuity, and much needed and appreciated humor, and, very importantly, focuses on Embry-Riddle Aeronautical University's mission. The old discussion board failed to connect mathematical learning outcomes to aeronautics, and simply noted that the content in the course would be utilized throughout their careers. The proposed discussion board clearly defines how and why the mathematics of GNED 103 is vital for student success. In addition, the discussion board properly advocates the use of technology, as emphasized by Garofalo et al., as this technology

allows students to accomplish a significant larger amount of work in the same timeframe as if students completed the work by hand.

Note that the current MyMathLab assignments in GNED 103 will be utilized to ensure continuity of Embry-Riddle Aeronautical University Worldwide curriculum. After several semesters of the new GNED 103 format, statistical review will be performed, and updates, modifications, and changes to the course will be implemented per suggestions by instructors and students. Learning objectives will be modified, more specifically the number of learning objectives met will be increased. Working with Embry-Riddle Aeronautical University Worldwide instructors across disciplines, the PI will correlate learning objectives from the course (undergraduate or graduate) that lend the discussion board project to the learning objectives of GNED. The PI will take suggestions from these instructors to design additional discussion board topics, ultimately generating three GNED 103 courses. Having three choices for students is beyond exciting, as it would allow students to choose a course that interests them, students and instructors alike will develop a sense of course ownership, and students who experience different GNED 103 sections will offer diverse perspectives to their aeronautical classes.

Conclusion

Embry-Riddle Aeronautical University Worldwide continues to lead the way in education by recognizing the need for educational reform through the implementation of Ignite. The Executive Summary clearly defines the goals of Embry-Riddle Aeronautical University as to prepare students to be the future leaders of the Aerospace Industry. Leaders must define their own paths and employ innovative solutions where none seem to exist. Learning subjects as disjoint entities works against Embry-Riddle Aeronautical University achieving this goal. There

is a great emphasis on the need for faculty to facilitate research that extends beyond a single curriculum. The above transitions demonstrate how research based learning, with an aeronautical theme, is seamlessly achieved in two mathematics courses. Furthermore the transition to aeronautical-relevant research-based learning has far greater benefits as it eliminates anxiety, fosters the implementation of cutting-edge technology, and harbors a sense of classroom ownership (hence developing dynamic, engaged leaders of the future). The PI will further this research by extending the ideas contained here-in to all the Embry-Riddle Aeronautical University Mathematics courses, creating an empowering learning environment for students. Given the rapid development of technology and massive amounts of information constantly draining the cognitive resources of our students, now is the time to Ignite the curriculum of Embry-Riddle Aeronautical University Worldwide to exceed the demands of the dynamic society students will face upon graduation.

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