20TH ANNUAL BOLLINGER-ROSADO

Teaching & Learning Effectiveness Symposium

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Research-Based Learning

Sponsored by the faculty of ERAU Worldwide

EMBRY-RIDDLE
Aeronautical University
WORLDWIDE

Twentieth Annual Bollinger/Rosado Teaching and Learning Effectiveness Symposium

Theme

Research Based Learning

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This symposium is dedicated to Dr. Art Rosado and Mr. John Bollinger who served Embry-Riddle and their country with pride and distinction. These two gentlemen set the standard for excellence in teaching at Embry-Riddle Aeronautical University Worldwide. By a unanimous vote of the faculty, this symposium is named in their honor.

Bollinger-Rosado Teaching & Learning Effectiveness Symposium

The purpose of the Bollinger-Rosado Teaching and Learning Effectiveness Symposium (TLES) is to foster the community of Embry-Riddle Aeronautical University scholars sharing research practices and findings to ignite academic discussions among faculty and the interested public. In 2011, at the bequest of the Worldwide Faculty Senate responsible for the TLES proceedings since 1991, the Rothwell Center for Teaching and Learning Excellence at the Worldwide campus (CTLE-W) began providing blind reviews of the papers selected by the Faculty Senate.

Each submission undergoes multiple blind reviews by a team of CTLE-W reviewers using the TLES Journal Article Reporting Standards Rubric covering both content and format. All of the submissions receive feedback for improvements, but only the top scoring paper is professionally edited by CTLE for this publication.

Contact information for the contributing authors, when provided, is included in the Author Note for each paper.

For more information on the TLES Rubric or CTLE-W, please contact Dr. Wendi Kappers, Director of CTLE-W, at kappersw@erau.edu or wwctle@erau.edu.

The Rothwell Center for Teaching and Learning Excellence – Worldwide Campus

The mission of the Center for Teaching and Learning Excellence at Embry-Riddle Aeronautical University-Worldwide (CTLE-W) is to be an educational beacon for all Faculty by providing developmental and pedagogical resources required for maintaining and improving didactical skills across educational modalities.

In 2010, the Worldwide Faculty Development Office was renamed as The Bruce A. Rothwell Center for Teaching and Learning Excellence and began offering additional faculty development courses. The four-week long instructor-led courses span topics from Blackboard learning management system, faculty orientation, and pedagogical exploration designed to strengthen the teaching skills of Worldwide faculty. CTLE-W services also include monthly EV-anars using the EagleVision (EV) in support of the University's Quality Enhancement Plan (QEP). CTLE-W currently serves approximately 1700 full-time and part-time faculty on a yearly basis.

To learn more about the CTLE-W, please visit http://erauctleww.com.

Panel of TLES 2012 CTLE-W Reviewers

- Amy E. Berger, M.Ed.
- Shannon Field, MA Ed
- Jan G. Neal, MAS
- Wendi Kappers, Ph.D.
- Sara Ombres, M.Ed.
- Kim Szathmary, MAS

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Disclaimer

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:

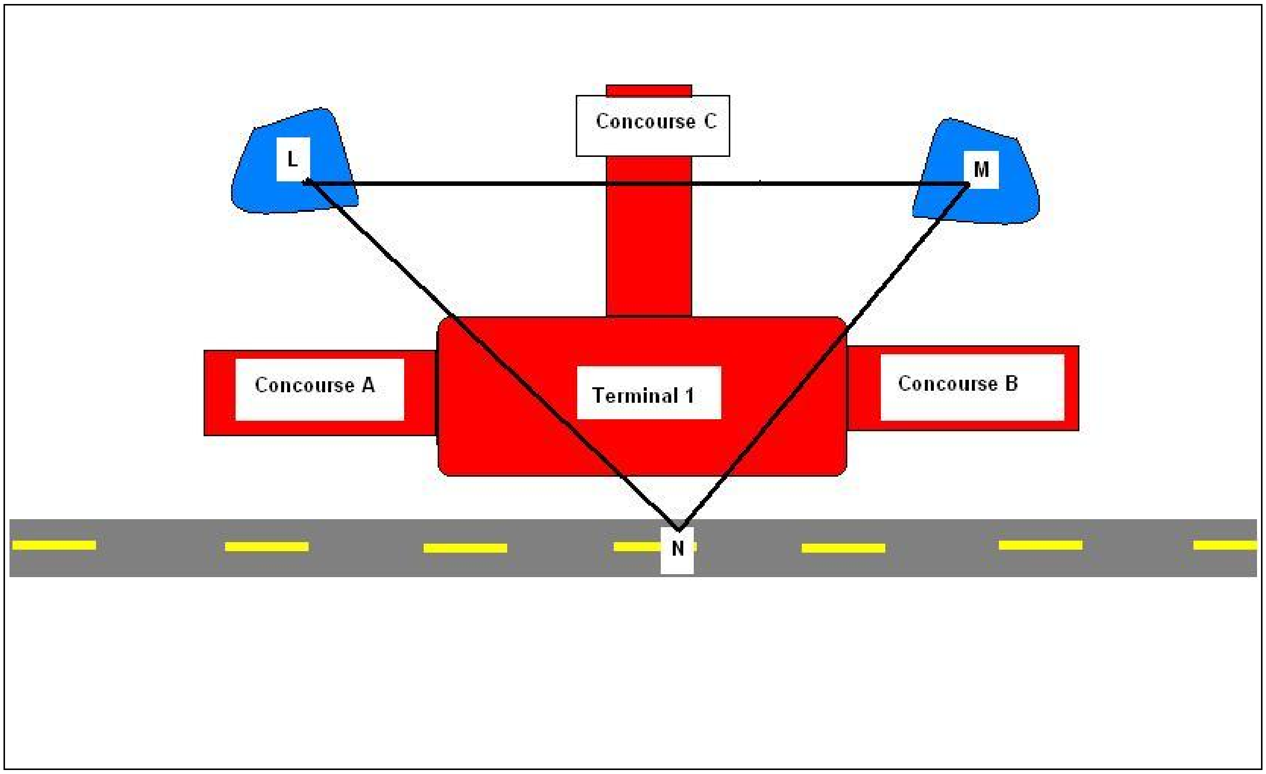

Figure 1. Solving a triangle problem.

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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SECTION B

The Relationship Between Transformational Leadership Styles and University Adjunct Faculty Work Engagement

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ABSTRACT

Adjunct faculty bring on-the-job experience and reality to the classroom. The problems associated with using adjuncts include lack of teaching experience, and not being fully engaged with the students. The purpose of this quantitative correlation study was to determine whether relationships exist among adjunct faculty work engagement and their perceptions of the transformational leadership styles of the campus academic director. Study participants were asked to respond to two validated and reliable survey instruments: the Multifactor Leadership Questionnaire (MLQ-5X) and the Utrecht Work Engagement Scale (UWES-17). Results revealed that all five transformational leadership styles of university campus academic directors showed a moderate to strong relationship to adjunct faculty work engagement ($p<.001$); Pearson's r ranged from .35 to .43.

Introduction

For a university to be a first-class institution of learning, it must have outstanding performing and fully engaged faculty to meet the ever-changing educational demands of the 21st century university student (Hainline et al., 2010; Hovey, 2011). Because teaching is a vital link to student success, faculty should master the subject being taught and have the ability to present the subject material as to ensure a student's academic progress (Aslam & Sarwar, 2010). University full-time faculty play a critical role in ensuring effective delivery of university-degree programs (Ballantyne, Berret, & Harst, 2010). However, financial considerations and the need to replace retiring full-time faculty have caused universities to employ an increasing number of adjunct (part-time) faculty members (Meixner & Kruck, 2010).

An important role of adjunct faculty is to enrich a university's curriculum by teaching courses in which they have particular areas of expertise. Therefore, the use of adjunct faculty provides the university a wide range of expertise they bring to foster learning success by teaching subjects involving real-world experience in the classrooms (Ballantyne et al., 2010). On the negative side, adjunct faculty are less engaged than full-time faculty with scholarly research, in acting as effective mentors to students outside the classroom, and in providing service to the university (Stenerson, Blanchard, Fassiotto, Hernadez, & Murth, 2010). To amplify the situation, more and more universities are required to report faculty work engagement as part of their response to demands of accountability for institutional effectiveness and accreditation (Tavanti, 2006). On the positive side, research has shown that when adjunct faculty feel that they are part of a collegial organizational culture and find meaning in their work, they are more likely to be engaged with their work (Colbeck & Wharton-Michael, 2006).

Work engagement is characterized by employees who are energetic, have a sense of connection with their work activities and are involved with the demands of their job (Schaufeli, Bakker, & Salanova, 2006). Work engagement has shown to be correlated positive employee attitudes, feeling energetic and enthusiastic, having proactive job behaviors, and increased individual job and organizational performance (Bakker, Shaufeli, Leiter, & Taris, 2008). Therefore, it is in the best interest for university management to explore every possibility fully to engage adjunct faculty for mission success (Ballantyne et al., 2010). In sum, both full-time and adjunct faculty should be fully engaged to maximize student engagement and university academic performance (Tavanti, 2006).

Consequently, it is imperative for a university's leadership to understand the factors that prompt adjunct faculty to be fully motivated and engaged with the university's operations and mission (Stenerson et al., 2010). Establishing individual and organization-wide rewards and incentives such as recognizing the faculty member of the month, quarterly, certificates, or increased academic rank are a few of the ways university management can begin creating an organizational environment that encourages motivation and engaged employees (Hongping, 2006). However, there is no significant evidence that such awards build adjunct faculty members' motivation or deepen their engagement to the university operations or mission (Glenn, 2010). Therefore, getting adjunct faculty fully engaged with their work is much more complicated than handing out these so called extrinsic motivational rewards (White, 2009).

One approach by which university management can accomplish this responsibility is by fostering an organizational work environment that assists faculty in finding true value and meaning in their work, which can lead to work engagement (Tipple, 2010). Research has shown that a faculty member that is actively involved in learning and participating in newer teaching techniques can translate that involvement into improved performance leading to increased quality and accountability (Trahant, 2009). Therefore, a university's management should study faculty work engagement to produce an environment that motivates faculty to action (Wade & Demb, 2009), and take necessary actions to improve the quality of teaching and student interaction by adjunct faculty (Ballantyne, 2010). Understanding how to inspire faculty work engagement can lead university academic directors to provide flexibility, inspire innovation and encourage adaptation to an ever-changing work and learning environment (Bresciani, Griffiths, & Rust, 2009). In sum, a university with an engaged adjunct faculty workforce will allow for a greater focus on student engagement, educational needs, instructional quality, and strengthening academic programs (Hongping, 2006).

A transformational leadership style has been shown to be correlated with many positive outcomes to include inspiring and stimulating employees to achieve extraordinary performance in accomplishing the organization's mission (Piccolo & Colquitt, 2008). The university campus academic director serves in a leadership role, and as such, is in a position to have a positive influence on adjunct faculty engagement. The specific problem is that it is not known if the perceived transformational leadership style of the campus academics director is associated with the level of work engagement among adjunct faculty. Without this information, stakeholders such as campus academic directors and other college administrators may not have all the information, they need to maximize adjunct faculty work engagement and thereby maximize student learning.

Research Question

The overarching research question guiding this study was: What, if any, relationship exists between work engagement and the perceived transformational leadership style of the campus academics director among assigned adjunct faculty at a degree-granting university located in the United States?

Literature Review

Faculty Engagement. Recent studies have noted that the level of faculty engagement and responsiveness at colleges and universities is an important facet of institutional quality and effectiveness (Stenerson et al., 2010). One study indicated that teachers who showed higher commitment to their work also reported greater engagement in the organization (Chan, Lau, Nie, Lim, & Hogan, 2008). However, research addressing university faculty engagement is limited largely to previous research concerning community service, service-learning, or community-based research (Wade & Dumb, 2009). Such research is important but the need for validation from professional organizations and accrediting bodies requires employment of full-time faculty to meet the responsibilities of teaching, curriculum development, and scholarly activity along with community service in the professorate, regardless of the institution size or research efforts (Stenerson et al., 2010).

To complicate matters, many colleges and universities facing financial challenges are employing increasingly larger numbers of adjunct faculty members to supplement classroom teaching (Hainline et al., 2010). Given the convenience and affordability of adjuncts, colleges and universities can benefit from what adjunct faculty members bring to the classroom in terms of their knowledge and experience gained from their daytime jobs or from their professions prior to retirement (VanderMeulen, 2008). Obviously, hiring adjuncts can be a sound move for colleges and universities that are trying to cut costs and still meet classroom mission requirements (Martinak et al., 2006).

To emphasize further the importance of engaging faculty, the need for adjunct faculty members at colleges and universities is predicted to grow over the next few years (Kerby, Harrison, & Fleak, 2009). Therefore, adjunct faculty's lack of teaching experience in the classroom must be addressed because students do not want to wait for an adjunct faculty member to become proficient in teaching at the collegiate level. In addition, the lack of departmental support for adjunct faculty is another issue, particularly at a large university. Moreover, adjunct faculty members typically do not have a campus office, and in many instances, their only contact with the campus is by email or visiting the campus directly. The good news is that assigning a full-time faculty member as the campus academic manager can provide the needed leadership to mentor and train adjunct faculty to offer sound instruction in the classroom. As a result, university campus academic managers should be proactive in addressing these issues to improve the role and use of adjunct faculty (Ballantne et al., 2010). However, to date, few studies have addressed faculty engagement, and none have addressed adjunct faculty engagement and such faculty member's perceptions of the leadership style of the campus academic director.

Methodology

The purpose of this quantitative correlation study was to investigate whether any correlations exist among campus- assigned adjuncts' work engagement and the perceived transformational leadership styles of the campus academic directors. Although a growing body of literature describes how engaged employees contribute to the overall success of a university, further studies are needed to determine factors related to university faculty engagement.

Understanding the factors that lead to faculty engagement will be valuable to university leadership in establishing a motivational work environment in which engagement can occur (Wade & Demb, 2009). For this present study, research was conducted to determine whether any relationship exists between the dependent variable of adjunct faculty work engagement and the independent variables of the perceived transformational leadership styles of the campus academic directors. In addition, basic demographic variables were collected for descriptive purposes, including gender, academic rank, educational level, number of university courses taught per annum, and assigned academic department.

Research Design. This research study used a quantitative correlation design to investigate the relationship between the styles of leadership of campus academic directors and adjunct faculty work engagement. A quantitative correlation research methodology was chosen for this study because it has the advantage of identifying attributes of a large population such as faculty located at campuses worldwide (Borrego, Douglas, & Amelink, 2009).

Hypotheses. The following null and alternative hypotheses were tested:

$H1_0$**:** No correlation exists between work engagement and the perceived attributed transformational idealized influence leadership style of the campus academic director among adjunct faculty.

$H1_a$**:** A correlation exists between work engagement and the perceived attributed transformational idealized influence leadership style of the campus academic director among adjunct faculty.

$H2_0$**:** No correlation exists between work engagement and the perceived behavior transformational idealized influence leadership style of the campus academic director among adjunct faculty.

$H2_a$**:** A correlation exists between work engagement and the perceived behavior transformational leadership style of the campus academic director among adjunct faculty.

$H3_0$**:** No correlation exists between work engagement and the perceived transformational inspirational motivation leadership style of the campus academic director among adjunct faculty.

$H3_a$**:** A correlation exits between work engagement score and the perceived transformational inspirational motivation leadership style of the campus academic director among adjunct faculty.

$H4_0$**:** No correlation exists between work engagement and the perceived transformational intellectual stimulation leadership style of the campus academic director among adjunct faculty.

$H4_a$**:** A correlation exists between work engagement score and the perceived transformational intellectual stimulation leadership style of the campus academic director among adjunct faculty.

$H5_0$: No correlation between work engagement score and the perceived transformational individualized consideration leadership style of the campus academic director among adjunct faculty.

$H5_a$: A correlation exists between work engagement score and the perceived transformational individualized consideration leadership style of the campus academic director among adjunct faculty.

H6o: The idealized influence attributed, idealized influence behavioral, inspirational motivation, intellectual stimulation, and individualized consideration leadership styles do not contribute independent information in predicting adjunct faculty work engagement.

H6a**:** The idealized influence attributed, idealized influence behavioral, inspirational motivation, intellectual stimulation, and individualized consideration leadership styles do contribute independent information in predicting adjunct faculty work engagement.

Data Collection Instruments. The components of Transformational Leadership that include Idealized Influence Attributed (IIA), Idealized Influence Behavioral (IIB), Inspirational Motivation (IM), Intellectual Stimulation (IS), and Individualized Consideration (IC), the independent variables, were measured using the Multifactor Leadership Questionnaire 5X (MLQ-5X). Adjunct faculty work engagement, the dependent variable, was measured using the Utrecht Work Engagement Scale Survey (UWES). These surveys were accompanied by a demographic survey asking the respondents to disclose the following information: gender, educational level, academic rank, academic department assigned, and number of courses taught at the university. The participation pool for this study consisted of adjunct faculty members assigned to a university's campus locations in the eastern United States. These campus locations offer undergraduate degrees, graduate degrees, and certificate programs via traditional classroom presentation, online, and the new modality of distance synchronous learning.

Data Collection Procedure. An e-mail invitation to participate in this study was sent to adjunct faculty assigned to university campuses located in the eastern region of the United States. Data were collected using an online survey hosted by SurveyMonkey.com. All survey responses were automatically coded numerically by the SurveyMonkey.com system. The data were exported from SurveyMonkey.com into a Microsoft Excel spreadsheet. The Excel spreadsheet was then imported into the SPSS software for analysis.

Analysis of Findings

This section provides results of the hypothesis testing completed on the dependent and independent variables used in this study.

Hypothesis 1

$H1_0$: No correlation exists between work engagement and the perceived attributed transformational idealized influence leadership style of the campus academic director among adjunct faculty.

$H1_a$: A correlation exists between work engagement and the perceived attributed transformational idealized influence leadership style of the campus academic director among adjunct faculty.

Table 1 shows there was a statistically significant, moderately positive relationship between the work engagement score and idealized influence attributed score, $r(148) = .41$, $p < .001$. Therefore, the null hypothesis was rejected, and it was concluded that there is strong evidence to suggest that adjunct faculty who perceive the campus academic director to have a high level of idealized influence attributed transformational leadership style tend to be more engaged with their work.

Table 1

Pearson's Correlation Statistics for Work Engagement versus Idealized Influence Attributed

		Idealized Influence (Attributed)
Work Engagement	Pearson Correlation	.406
	p-value	<.001
	N	148

Hypothesis 2

$H2_0$: No correlation exists between work engagement and the perceived behavior transformational idealized influence leadership style of the campus academic director among adjunct faculty.

$H2_a$: A correlation exists between work engagement and the perceived behavior transformational leadership style of the campus academic director among adjunct faculty.

Table 2 shows there was a statistically significant, moderately positive relationship between the work engagement score and idealized influence behavioral score, $r(148) = .40$, $p < .001$. Therefore, the null hypothesis was rejected, and it was concluded that there is strong evidence to suggest that adjunct faculty who perceive the campus academic director to have a high level of idealized influence behavioral transformational leadership style tend to be more engaged with their work.

Table 2

Pearson's Correlation for Work Engagement versus Idealized Influence Behavior

		Idealized Influence (Behavioral)
Work Engagement	Pearson Correlation	.400
	p-value	<.001
	N	148

Hypothesis 3

$H3_0$: No correlation exists between work engagement and the perceived transformational inspirational motivation leadership style of the campus academics director among adjunct faculty.

$H3_a$: A correlation exits between work engagement score and the perceived transformational inspirational motivation leadership style of the campus academics director among adjunct faculty.

Table 3 shows there was a statistically significant, moderately positive relationship between the work engagement score and inspirational motivation transformational leadership score, $r(148) = .43$, $p < .001$. Therefore, the null hypothesis was rejected, and it was concluded that there is strong evidence to suggest that adjunct faculty who perceive the campus academic director to have a high level of inspirational motivation transformational leadership style tend to be more engaged with their work.

Table 3

Pearson's Correlation for Work Engagement versus Inspirational Motivation

		Inspirational Motivation
Work Engagement	Pearson Correlation	.430
	p-value	<.001
	N	148

Hypothesis 4

$H4_0$: No correlation exists between work engagement and the perceived transformational intellectual stimulation leadership style of the campus academic director among adjunct faculty.

$H4_a$: A correlation exists between work engagement score and the perceived transformational intellectual stimulation leadership style of the campus academic director among adjunct faculty.

Table 4 shows there was a statistically significant, moderately positive correlation between the work engagement score and intellectual stimulation transformational leadership score, $r(148) = .35$, $p < .001$. Therefore, the null hypothesis was rejected, and it was concluded that there is strong evidence to suggest that adjunct faculty who perceive the campus academic director to have a high level of intellectual stimulation leadership style tend to be more engaged with their work.

Table 4

Pearson's Correlation for Work Engagement versus Intellectual Stimulation

		Intellectual Stimulation
Work Engagement	Pearson Correlation	.350
	p-value	<.001
	N	148

Hypothesis 5

$H5_0$: No correlation between work engagement score and the perceived transformational individualized consideration leadership style of the campus academic director among adjunct faculty.

$H5_a$: A correlation exists between work engagement score and the perceived transformational individualized consideration leadership style of the campus academic director among adjunct faculty. Table 5 shows there was a statistically significant, moderately strong positive correlation between the work engagement score and individualized consideration score, $r(148) = .34$, $p < .001$. Therefore, the null hypothesis was rejected, and it was concluded that there is strong evidence to suggest that adjunct faculty who perceive the campus academic director to have a high level of individualized consideration leadership style tend to be more engaged with their work.

Table 5

Pearson's Correlation for Work Engagement versus Individualized Consideration

		Individualized Consideration
Work Engagement	Pearson Correlation	.337
	p-value	<.001
	N	148

Hypothesis 6

H6o: The idealized influence attributed, idealized influence behavioral, inspirational motivation, intellectual stimulation, and individualized consideration leadership styles do not contribute independent information in predicting adjunct faculty work engagement.

H6a: The idealized influence attributed, idealized influence behavioral, inspirational motivation, intellectual stimulation, and individualized consideration leadership styles do contribute independent information in predicting adjunct faculty work engagement.

A multiple linear regression analysis was performed to test this hypothesis. First, a correlation matrix of the five transformational leadership styles was produced in order to evaluate the potential for a multicollinearity problem. As a result of the high multicollinearity among the five transformational leadership style scores, instead of entering all five leadership styles scores into the model simultaneously, the variables were entered into the model using a stepwise model selection procedure. Only those transformational leadership style scores that were statistically significant at the .05 level of significance were entered into the model. Other assumptions for linear regression were evaluated. The normal probability plot was inspected and there was no indication of a violation of the normal assumption was violated. A scatter plot of the standardized residuals against the standardized predicted values did not give an indication of a violation of the constant variance assumption.

The independent variables entered into the stepwise model selection procedure were the idealized influence attributed, idealized influence behavioral, inspirational motivation, intellectual stimulation, and individualized consideration transformational leadership style scores. Table 6 shows that only the inspirational motivation leadership style score was statistically significant, $F(1, 146) = 33.1$, $p < .001$. The R^2 attributed to the model was .19, which means inspirational motivation explains 19% of the total variance in work engagement scores.

Table 6

Stepwise Multiple Linear Regression Scores

		Unstandardized Coefficients		Standardized Coefficients		
Independent Variables [a, b]		B	Std. Error	Beta	T	p-value
1	(Constant)	3.558	.171		20.852	< .001
	Inspirational Motivation	.311	.054	.430	5.752	< .001

a. Dependent Variable: Work Engagement

b. $F(1,146) = 33.1$, $p < .001$, $R^2 = .19$

The equation of the model was: WE = 3.56 + .31*IM, where: WE = Work Engagement, and IM = Inspirational Motivation. The interpretation of the model is the average work engagement score is expected to increase by .31 points for every one-point increase in the inspirational motivation score. Since only one of the five transformational leadership style scores was statistically significant, the null hypothesis was not rejected. It was concluded that combinations of transformational leadership styles do not collectively contribute to better predict work engagement than any single transformational leadership style alone. It was further concluded that, among the five transformational leadership styles, inspirational motivation was the strongest predictor of adjunct faculty work engagement.

Summary

The purpose of this quantitative correlation study was to determine whether a relationship exists between the dependent variable of adjunct faculty work engagement and the independent variable of perceived transformational leadership style of the campus academic directors. If one or more transformational leadership styles were found to be positively correlated with faculty work engagement, then university campus academic directors may wish to adopt a certain transformational leadership style in an effort to have a positive influence on the adjunct faculty. A change in leadership style, in turn, could have such positive effects on a university as a higher level of instructional quality and use of new classroom teaching methodologies and technologies.

The present study results revealed that perceived transformational leadership styles of the campus academic directors were moderately correlated with adjunct faculty work engagement. In addition, it was concluded that combinations of transformational leadership styles do not collectively predict work engagement better than any single transformational leadership style alone. It was further concluded that, among the five transformational leadership styles, inspirational motivation was the strongest predictor of adjunct work engagement. Ideally, the results of this present study will help university campus academic directors to take a more positive approach to stimulating faculty work engagement to meet the university's academic mission and goals.

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SECTION C

Teaching the Next Generation of Researchers: An Inquiry into Aviation Research Education

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ABSTRACT

Research in aviation fields has become increasingly important to institutions and their faculty. Expectations to conduct such research have escalated with tenure and employment decisions often hanging on evidence of research skill and advanced educational attainment. Considering the importance of research to aviation higher education, this study investigated how research skills are conveyed to undergraduate and graduate aviation students. Further, the subjects and methods of instruction were evaluated. This inquiry was guided by content analysis. To bolster the findings of this study, a series of interviews with program directors and faculty teaching research courses were conducted to explore faculty perceptions on research education as well the as strengths and weaknesses of such education and the students enrolled in research courses.

Keywords: research, education, aviation, content analysis, interviews, research-lead education

Introduction

The ability to conduct research is a skill that is essential for every scholar. For any field of study to move forward and discover new and innovative knowledge, research must be conducted. The non-engineering aviation field is no exception. Further, this research must be directed in a sound manner so as not to come to flawed conclusions. Perhaps most important is the ability to disseminate the findings of such research in coherent, succinct writing. Thus, it is essential that there be a well-educated, skilled, capable assemblage of aviation researchers to provide for the continued improvement of the field and expand the associated knowledge base (Johnson, Hamilton, Gibson, & Hanna, 2006; Wright, 2005).

The recognition of the importance of research has appeared frequently in a wide range of literature. Wright (2005) has stated that research was the “lifeblood, hallmark or cornerstone in the development of a profession” (p. 4). Anderson (2011) has stated:

> Research is an important activity in the business and scientific communities as well as in virtually every academic discipline . . . . In higher education, learning how to conduct valid research prepares students for their future professional lives, and it certainly enhances the learning process. (Section A)

So not only does research education help students when they enter their real-world professions, it is also critical to those individuals who wish to pursue graduate education, because research becomes more and more important the further one proceeds beyond the bachelor’s degree.

However, one challenge to aviation research education is that “only in the last twenty years . . . . non-engineering aviation scholarly research journals began to appear. Prior to the recent emergence of new scholarly journals, aviation education researchers had only a limited number of publishing opportunities available to them” (Johnson, Hamilton, Gibson, & Hanna, 2006, p. 82). Thus, aviation research has only recently become a priority in the field. This fact is reinforced by the statement that the “lack of definition and recent emergence of aviation peer-reviewed journals has led some to define aviation education as an ‘emerging discipline’” (Johnson, et al., 2006, p. 83). In a sense, aviation education has been expected to prove itself as a viable and productive research community: “as aviation education establishes itself in academia, it must continue to advance the discipline by creating a rich depository characterized by scholarship and inquiry” (Johnson, et al., p. 83). As such, even in light of its neophyte presence, the expectations of quality contributions are just as high for aviation researchers as for those in other subject areas. Moreover, current and future aviation faculty are facing increasing pressure to conduct and report research to the academic and industry communities.

The problem is that there must be a sound research education system in place to encourage inquiry and to produce excellence in results. Unfortunately, many researchers lack the skills necessary to perform competent inquiry (Pato & Pato, 2001). Ning, Murphy, and Jinks (2010) stated that a “lack of knowledge and skills in relation to research methodologies appeared to be important inhibitors [*to conducting studies*], with educators saying they needed more help to develop their research skills” (p. 539). Advanced research was not a priority for non-engineering aviation faculty until recently. This was evident by the fact that most aviation faculty do not hold a doctorate degree and, in a study by Ison (2009), only about 10% of professional pilot education faculty were found to have some form of doctorate degree. However, this appears to be changing, albeit slowly. In an analysis of aviation faculty employment advertisements, a master’s degree was the minimum educational requirement in over 71% of the positions advertised, but a doctoral degree was the employment preference in more than 66% of the positions (Ison, 2009). The difference between the rate of preference for the doctorate and the prevalence of such a degree among faculty at those institutions was found to be statistically significant; thus, the expectations for advanced training in research appear to be on the rise (Ison, 2011). A likely contributor to this problem is the fact that the non-engineering aviation area of study only gained its own, focused Ph.D. program in 2009 (Embry-Riddle Aeronautical University, 2009).

Because of the importance of research skills and performance in a wide range of fields, there has been a significant amount of inquiry into research education. While entry or lower level research courses understandably focus on an introduction to methods, successful conveyance of the knowledge and talents required of capable, proficient researchers was reported to require a more hands-on, practical approach (Crull & Collins, 2004; España, 2004; Jinks, 2010; Ning, Murphy, Upchurch, Brosnan, & Grimes, 2002; Pato & Pato, 2001). For example, Healy, Jordan, Pell, and Short (2010) recognized that students are more engaged and benefit greatly when immersed in research conducted with faculty currently involved in such activities. The term *research-led* has been used to describe the approach where students are compelled to shift from being passive participants to active practitioners through the use and practice of authentic, applied research skills (LaBeouf, 2011).

Pato and Pato (2001) have advocated for a building-block style approach to teaching research skills. In their study, initially the students were introduced to general research methods, then shown examples of research in the format of studies and journal articles, and subsequently asked to write up their findings. In addition, the students were given instruction on how to pursue publication and critique peer research. Upchurch, Brosnan, and Grimes (2002) promoted a similar construction of competencies beginning with teaching students how to find literature using modern databases. Next, the students were required to examine existing research and build the foundations of a literature review. Additional tasks were assigned to gain familiarity with research design, appropriate data collection, and analysis of findings.

España (2004) explored this issue from a more academic perspective by advocating for research-led education based on the hierarchy of critical-thinking skill development. Basic researcher courses fall into the first level of theoretical development called dualism. At this stage, students rely heavily on the instructor for guidance as to what is correct or incorrect. Often such lower level courses also fall into the multiplicity stage where students know there are many alternatives, but are not able to distinguish which is the best or most appropriate to choose. In more advanced research coursework, learners reach the contextual realism phase where they discover that their positions must be supported by extant literature (España, 2004). Research-led learning, the highest level, requires the attainment of the dialectic stage where students interpret the results and thereby give meaning to the findings and provide new knowledge (España, 2004). Reaching the highest level is generally accepted to be impossible without applicatory tasks and practice (Crull & Collins, 2004; España, 2004; LaBeouf, 2011; Ning, Murphy, & Jinks, 2010; Upchurch, Brosnan, & Grimes, 2002; Pato & Pato, 2001).

Taking the realism in research a step further, Crull and Collins (2004) supported a confidence boosting events such as poster session and conference participation. Yet, this step is perhaps too often minimalized. As Sullivan and Maxfield (2003) argued, it is a seminal component of scientific socialization in which individuals are introduced to:

> The standards of the [*research*] paradigm . . . . through the teaching and writing of scholars who are already established in the field. Students are socialized to follow the central norms of the paradigm through their study with experienced instructors and the readingof scholarly work. Doctoral students are expected to internalize and embrace the

> elements of the paradigm if they wish to become a part of the scientific community. (p. 269)

Therefore, students of research can only expect to become practitioners by seeing and doing what actual researchers do and are expected to do within their field of study.

If the edification of researchers is essential for the proliferation of research, then knowledge of how and what research is taught is clearly an indispensable piece of the process. Content analysis is a research method used to uncover common information in the literature. Sullivan and Maxfield (2003) conducted a content analysis of 54 doctoral research course syllabi. The method was justified as it provided for a logical means of evaluating course materials (Sullivan & Maxfield, 2003). The documents were coded to identify course type, themes, and assignments.

Lu (2007) also used content analysis to evaluate 43 introductory doctoral-level syllabi for key items such as frequency and quantity of contact time, textbooks, readings, objectives, topics, assignments, assessment tasks, ethics, plagiarism, and format/citation methods. Drisko (2008) used a mix of surveys and content analysis to examine how research was taught at the master's level in social work. A total of 48 syllabi and 57 surveys were collected. The content analysis of the syllabi was focused on research frequency/quantity of contact, methods taught, readings, and assignments. The survey was constructed of six descriptive questions focused on overall content, program construction, and the presence of practical application.

Identifying more information that can be gleaned from content analysis of syllabi has been helpful in identifying the complexities of research education, Ning, Murphy, and Jinks (2010) conducted a survey of 72 healthcare research educators. They collected data on faculty attitudes and experiences concerning research. Only 22% had their research findings published and just under 20% had participated in funded research. Only 37% of the faculty were *likely* or *highly likely* to volunteer to teach research. It certainly could potentially be detrimental to the teaching of research if those conducting such classes had limited experience in peer-reviewed research or funded projects. Further, if they were not interested in teaching the subject, this could theoretically have a negative effect on the classroom environment (Ning, Murphy, & Jinks, 2010).

There is clear evidence that research has recently become an increasingly important component of the non-engineering aviation field and to faculty within that field. The literature synthesis also indicates a growing level of expectation for the level of aviation faculty educational attainment and research skill (Ison, 2011). There is a range of studies on the evaluation of research education because of its critical nature to virtually all areas of study in higher education; however, there are few studies on both what and how research is taught in aviation (Ison, 2009; Johnson, Hamilton, Gibson, & Hanna, 2006; Wright, 2005). This study addresses these gaps in the literature.

Method

This study entailed a content analysis of non-engineering aviation undergraduate and graduate research courses taught at University Aviation Association (UAA) member institutions. Additionally, interviews were conducted from which the resultant data was also analyzed with content analysis.

Participants. The most recent UAA institutional membership list was utilized to identify schools that are four-year institutions to be included in the study (UAA, 2012). A total of 63 aviation institutions were identified among which 18 offered graduate degrees. The institution websites and course catalogs were mined to identify research courses and major requirements at both the graduate and undergraduate levels. A purposive sample of 11 program directors/chairs/managers was selected to insure a range of institution types (public and private), focus (aviation-oriented and liberal arts), as well as program size (from under 100 to 5,000 students). See Appendix A for the list of included institutions. Each individual was contacted to participate in the interview and course syllabi phase of this study.

Materials and Procedure. The first step in the analysis was to identify the type and number of institution-wide research-related courses. Next, the numbers of writing-specific courses within each program were quantified. Course descriptions were collected for each aviation-specific course identified that conveyed research methods or built research skills. These were then evaluated via content analysis. The content analysis process was modeled on the guidance provided by Berg (2007), Krippendorff (2004), Neuendorf (2002), and Okunus and Wong (2007). Additional theme identification strategies used in the research education literature served as a guide to this study (Drisko, 2008; Lu, 2007; Sullivan & Maxfield, 2003). Further, the guidance of Riffe, Lacy, and Fico (2005) to use literature-based measures and create standardized coding sheets were utilized to properly manage the data. Initially, open coding was used to gain insight into the overarching themes within the course descriptions and syllabi (Berg, 2007). Mutually exclusive categories were defined by the guidance of Weber (1990). A final codebook was created to ensure the standardization of analysis across the data (Krippendorff, 2004; Neuendorf, 2001; Riffe, Lacy, & Fico, 2005). Additional guidance on codebook construction was garnered from a similar study on syllabi by Ison (2010). Prior to examining sample data, test coding was conducted on non-aviation-related research course materials (Weber, 1990).

To further supplement the findings of the content analysis, a series of brief interviews was conducted with the program directors or faculty teaching research courses. Contact data was collected from UAA program listings. The interview questions were constructed based upon existing studies on research education and were pilot tested on a group of non-participating aviation faculty (Crull & Collins, 2004; España, 2004; LaBeouf, 2011, Ning, Murphy, & Jinks, 2010; Pato & Pato, 2001; Upchurch, Brosnan, & Grimes, 2002). These efforts resulted in a standardized interview protocol providing a semi-structured approach that will allow flexibility to probe for more detailed data from each individual (Berg, 2007; Kvale & Brinkmann, 2008). The protocol was reviewed by a panel of education and aviation higher education faculty that fell outside the target sample. Feedback was integrated into the final draft of the protocols. Individuals were initially contacted by email to request their participation (Kvale & Brinkmann, 2008). For those that agreed to participate, interviews were conducted via telephone due to the geographic distribution of faculty (Creswell, 2003). Responses were categorized by each question of the instrument. Each of these responses was analyzed via content analysis to identify themes and commonalities. The interview instrument is included in Appendix B. Free Mind software was used to map the themes identified in aviation-specific course descriptions.

Operational Definitions. For the purposes of this research, the following operational definitions provided bounds for the study:

- Research: “research is simply the process of arriving at a dependable solution to a problem through the planned and systematic collection, analysis and interpretation of data” (Singh, 2006, p. 1).
- Research methods: “the general approach the researcher takes in carrying out the research project […] this approach dictates the particular tools the researcher selects” (Leedy &

Ormrod, 2010, p. 12). Examples of methods include, but are not limited to descriptive research, correlation research, experimental research, non-experimental research, quasi-experimental research, quantitative methods, qualitative methods, and mixed methods (Stangor, 2007; Weathington, Cunningham, & Pittenger, 2010).

- Research skills: critical thinking, problem solving, analysis, and dissemination. Examples of research skill building was students autonomously conducting research, analyzing data, and reporting findings in the form of prescribed documentation (e.g., theses, reports, capstone papers) (University of Sydney, 2012).

Results

Research Courses. Among the 63 undergraduate programs analyzed, 23 (36.5%) included non-aviation research courses in their curricula while only three (4.7%) had aviation-specific research-related courses. The mean number of non-aviation research courses per program was 0.51 (*SD* = 0.68) and the mean aviation-related research courses per program was 0.03 (*SD* = 0.17). Undergraduate programs had a mean of 1.67 writing courses (*SD* = 0.94). There were 11 (17.4%) programs that had no required writing-intensive courses.

Of the 18 graduate programs that were identified, 15 (83.3%) included non-aviation research oriented courses and eight (44.4%) had aviation-specific research courses. The mean number of non-aviation research courses was 0.72 (*SD* = 1.42) and the mean aviation-related counterpart was 0.36 (*SD* = 0.96). All graduate programs had at least one requisite writing course, most commonly a capstone or thesis requirement. See Figures 1 and 2 for a summary of the research course type distribution among programs.

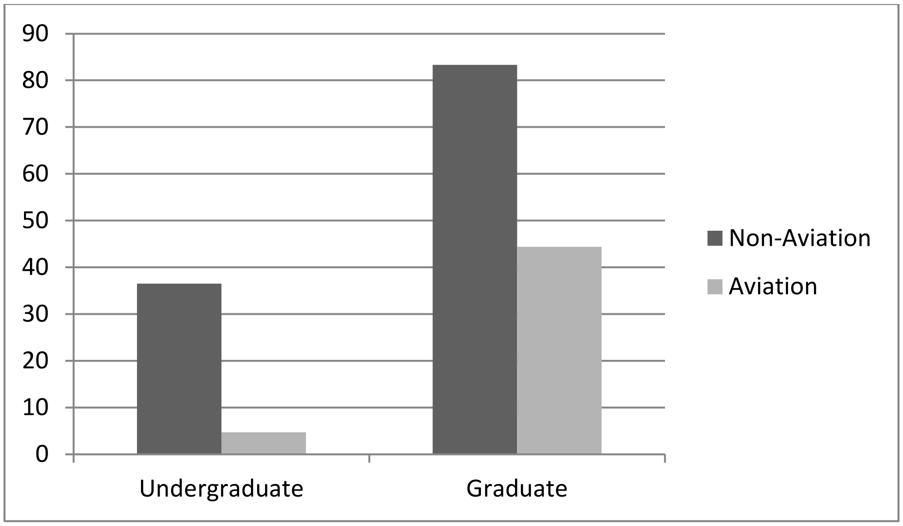

Figure 1. Percentage of programs with non-aviation specific and aviation specific research courses.

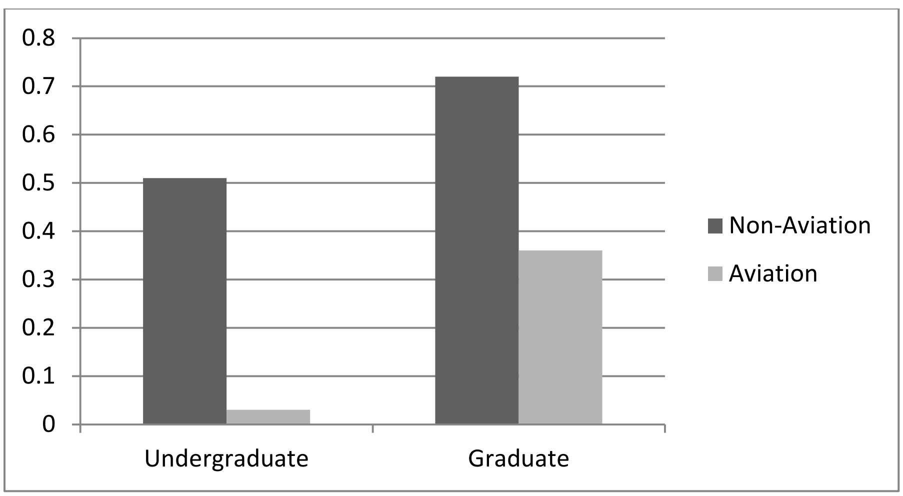

Figure 2. Mean number of non-aviation specific and aviation specific research courses per program.

Undergraduate research course themes. Undergraduate research-related courses were concentrated in five subject areas. The largest grouping comprised of courses with a mathematics/statistics program prefix. The remaining prefixes included English, business, psychology, and aviation-related. Figure 3 shows the distribution of course prefixes. The common theme among statistics-based courses was the majority were “introduction to,” “introductory,” “elements of,” “elementary,” “understanding,” or general classes on the subject. More focused statistics courses were identified, but were singular in numbers and included “economic,” “business,” and “experimental” statistics. Research-specific courses included the following key terms:

- Operational research
- Research methods
- College writing and research
- Introduction to writing and research
- Analysis, research, and documentation
- Research and argumentative writing
- Business quantitative methods
- Library research skills.

Aviation-specific research courses were limited to “performance evaluation and measurement” and “research methods.”

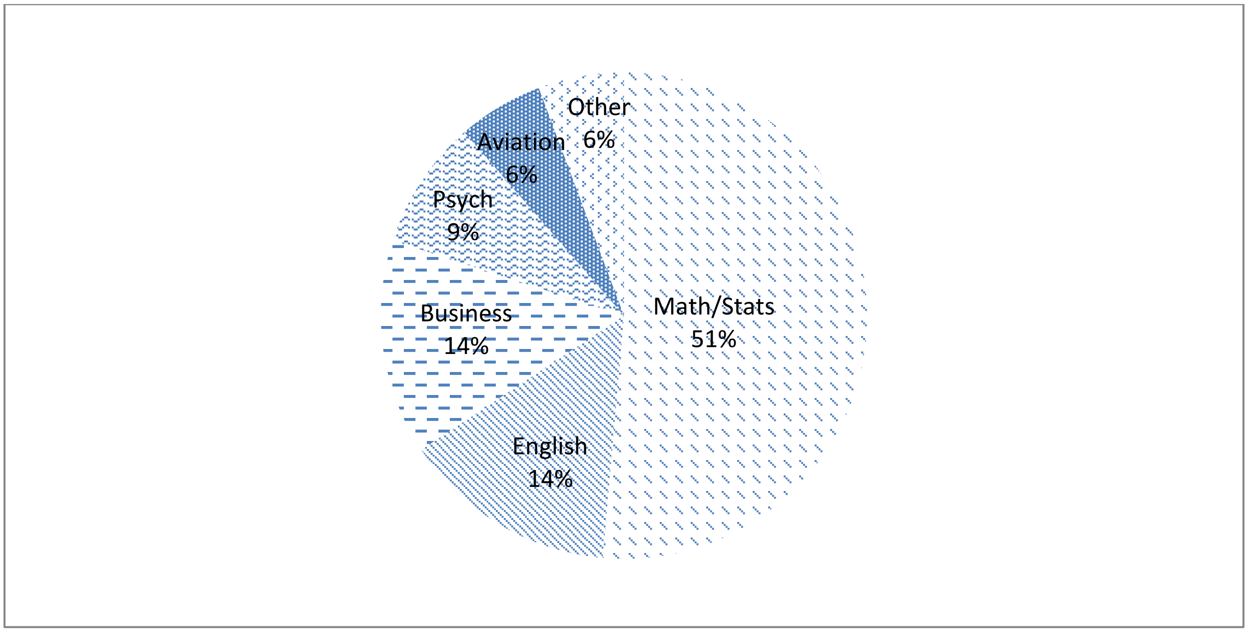

Figure 3. Distribution of undergraduate course program area prefixes.

Graduate research course themes. Master's level research courses most commonly incorporated the title "research methods" of which the majority fell under aviation program prefixes (see Figure 4). Other course titles included:

- Quantitative methods
- Qualitative methods
- Statistical analysis
- Theoretical foundations of inquiry
- Experimental statistics
- Research in safety.

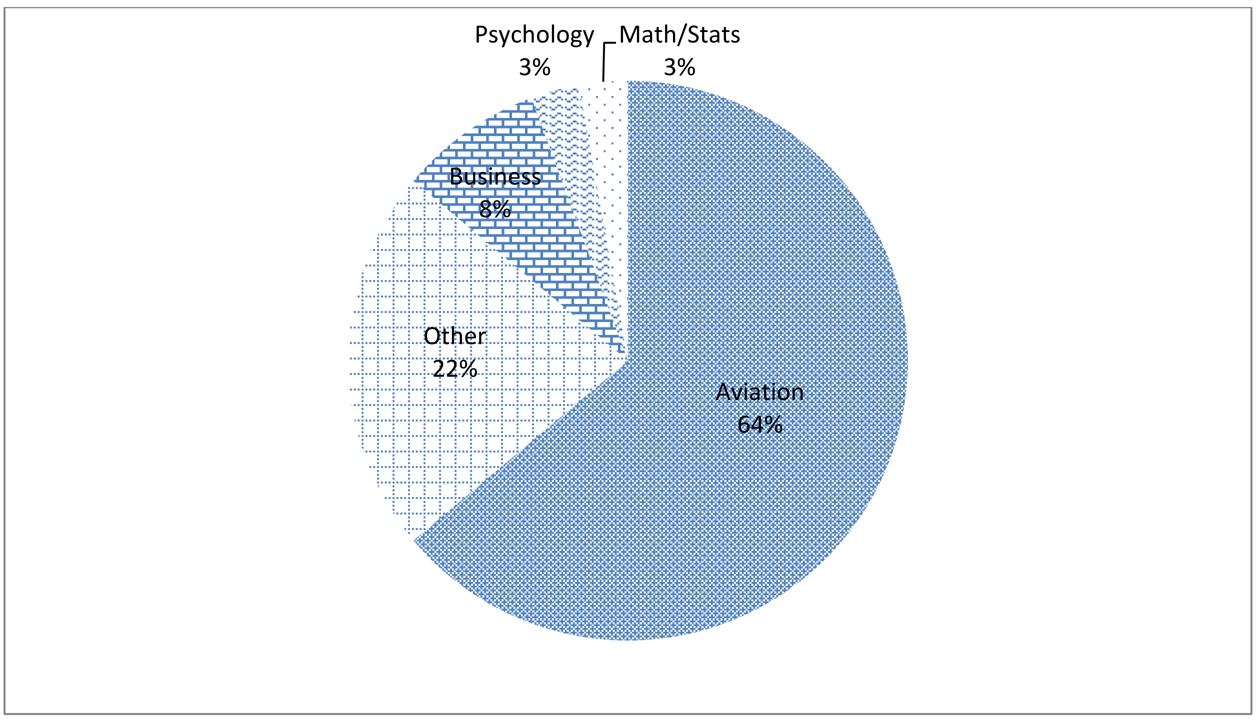

Figure 4. Distribution of graduate course program area prefixes.

Aviation Courses. Aviation specific research courses were more common at this level of study. Among master's aviation research courses were the following course titles:

- Research and statistics
- Advanced aviation research project
- Research methods in aviation
- Introduction to aviation research
- Applied statistics in aviation research
- Thesis research
- Applied research
- Case research
- Individual research in aviation
- Readings in aviation
- Analysis of aviation research

In addition, a variety of thesis or capstone courses existed at graduate institutions. At the doctoral level, more advanced courses were offered. These included:

- Advanced quantitative methods
- Applied multivariate statistics
- Mixed methods
- Advanced quantitative data mining
- Operations research
- Qualitative research
- ANOVA
- Multiple regression
- Multivariate statistics
- Qualitative and alternative methods

- Experimental design and research methods

Course description themes. The course descriptions of the aviation courses were analyzed for themes. The data were grouped by undergraduate and graduate courses.

Undergraduate course description themes. The three aviation research courses identified in this study covered very basic concepts and did not appear to explore any detailed research methods. One of the courses was described as "directed research on a topic not covered in organized classes." The other courses covered the following:

- Performance metrics and analysis
- Performance criteria from metrics
- Performance measurement
- Writing a research paper
- Interpreting data
- Analyzing data
- Written and oral communications
- APA format.

In terms of tasks required in these courses, two required an in-depth term-type paper. The other course derived the course grade from three tests, a case analysis, and a presentation. No specific methods, statistical analysis, or other key research terms or tools, were described or mentioned.

Graduate course description themes. There were 26 aviation-specific graduate courses analyzed. Course descriptions indicated content subject matter ranging from the very basic levels to very specific course focus. A course titled with the word "research" generally mentioned the inclusion of research methods with some specifically identifying qualitative, quantitative, and/or mixed methods. Four (15.3%) of these courses combined research methods and statistics. Among the 26 courses, eight (30.7%) were titled with the word “statistics.” See Figure 5 for the distribution summary.

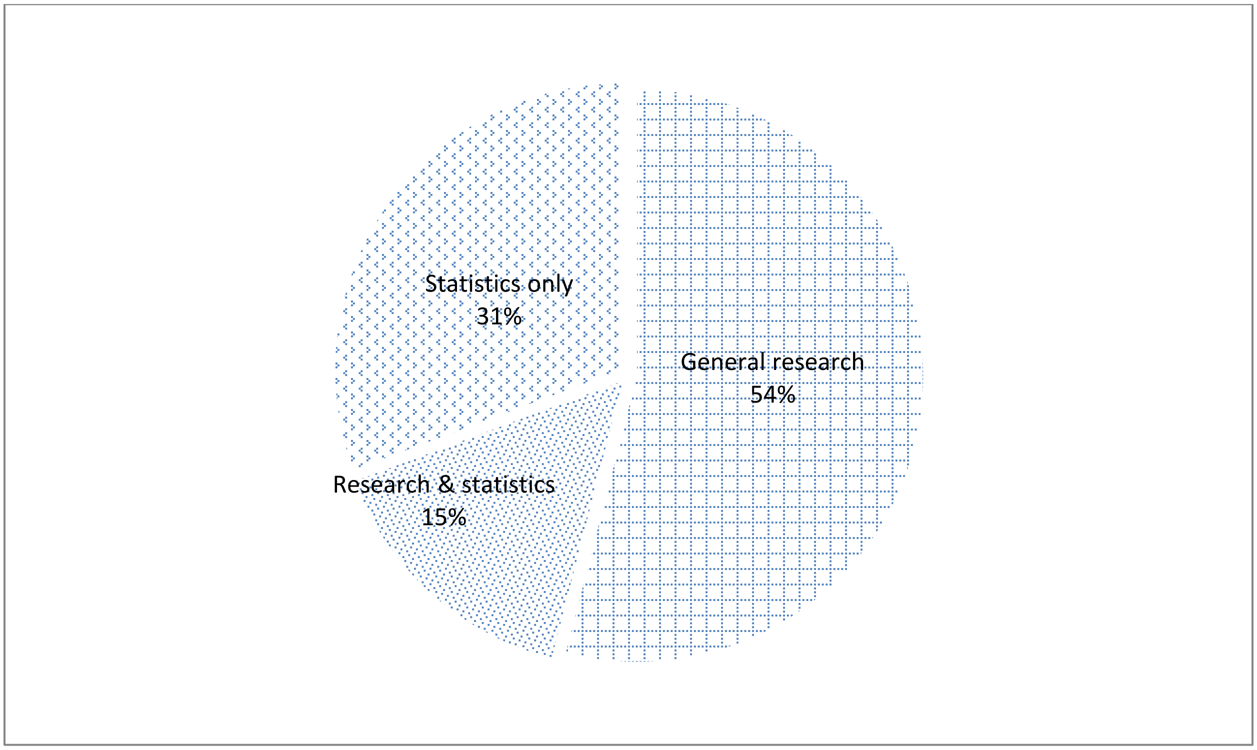

Figure 5. Percent distribution of graduate research course content.

During the thematic analysis of the courses, several common threads existed among the descriptions. The following were the most commonly mentioned items:

- Research methods
- Quantitative methods
- Qualitative methods
- Research problem
- Statistics
    - Parametric
    - Non-Parametric.

The remaining content of the course descriptions was somewhat scattered. Therefore, mind mapping software (Free Mind, n.d.) was employed to develop a depiction of the chain of related subjects (see Figure 6).

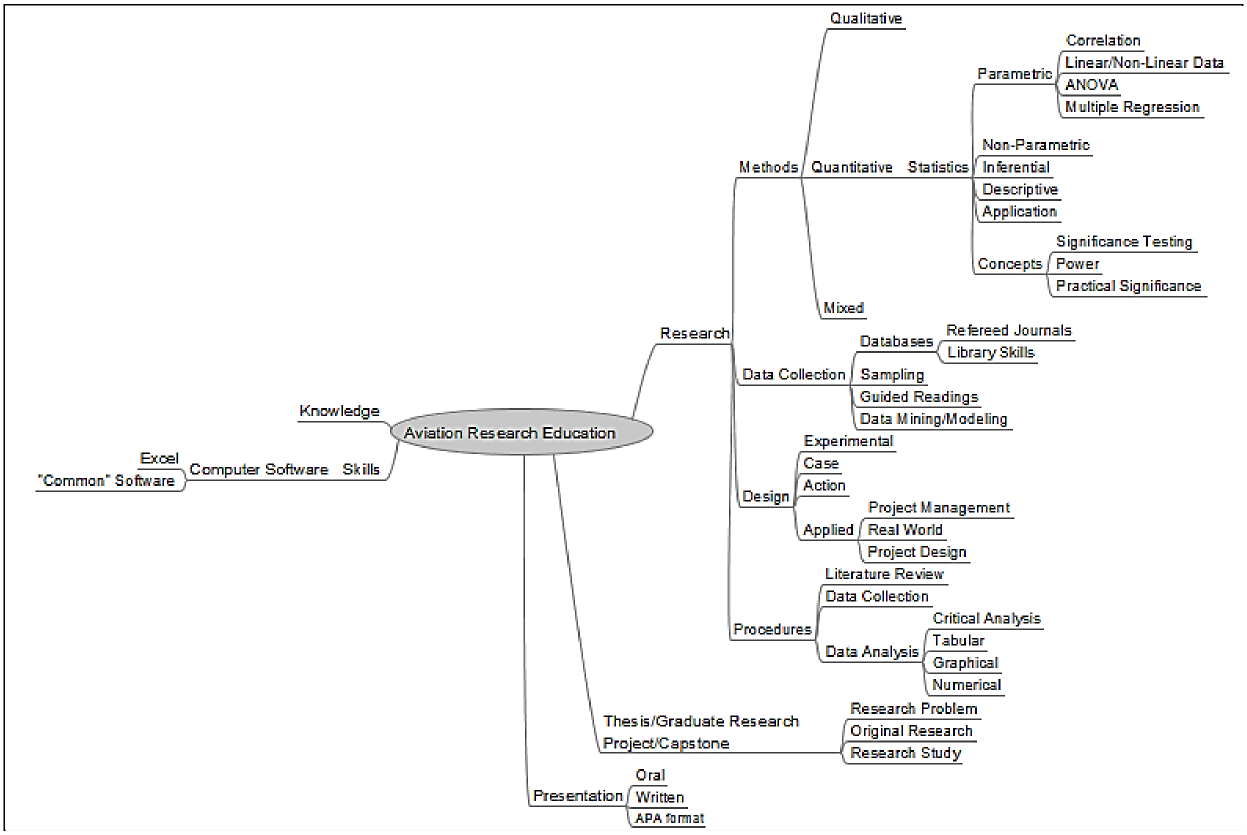

Figure 6. Mind map of themes identified in aviation-specific graduate course descriptions.

Undergraduate course syllabi. Three undergraduate syllabi were collected. There were few common traits among the syllabi. Two required written tasks as well as oral presentations. One course mentioned the requirement to demonstrate digital communication. In terms of required graded activities, one syllabus noted that the entire grade for the course was based upon the completion of a research paper. Another course used a combination of scores on homework, exams, and quizzes, and class attendance for the course grade. The remaining course required students to take a comprehensive exam that was the only graded activity. One of the courses was highly statistically based. It covered statistical analysis software, sampling, parametric and non-parametric tests, and quantitative reasoning. Another course mentioned analysis and interpretation of data as well as data collection. This same course described American Psychological Association (APA) citations and references would be covered and expected to be mastered. No coverage of research methodology was apparent in any of the syllabi. Lastly, the textbooks used in these courses were examined. The following text titles were used:

- Introductory statistics
- Publication Manual of the American Psychological Association.

Graduate course syllabi. The eight graduate syllabi analyzed were much more specific in terms of the content covered. In addition, there was much more focus on research method, design, and statistical analysis compared to the undergraduate syllabi. Major themes common among the graduate syllabi were coverage of research design and methodology, statistical analysis, proposal development, research questions, written and oral presentations, and attention to formatting. Some syllabi were more specific about research and included the following in addition to the aforementioned focus areas:

- Collection of data
- Ethics in research
- Independent and dependent variables
- Validity
- Reliability
- Literature reviews
- Experimental research
- Populations and samples
- Sampling

- Controls.

Statistical instruction appeared to be more thorough in the graduate courses. Although only half of the syllabi included detail about the types of statistical analysis that would be covered, all mentioned statistical analysis as a subject area. The following were mentioned specifically among the syllabi:

- Descriptive statistics
- Inferential statistics
- Correlation
- Statistical significance.

In three of the syllabi, more advanced statistics were specifically described. Among these syllabi, the following tests were mentioned:

- Confidence intervals
- *t*-test
- ANOVA: One-way and factorial
- Multiple regression
- Chi square
- RBANOVA
- SPANOVA
- ANCOVA.

One course specifically mentioned the attainment of confident use of SPSS software. The functions that students were required to learn to use in SPSS were:

- Descriptive statistics
- Graphing

- Interpreting results
- Parametric and non-parametric tests.

Other subjects that were covered were APA formatting rules and instrument development.

The evaluation of performance in the courses varied. All courses employed some form of writing exercise that was a portion of the course grade. Also, a majority included exams or quizzes for assessment. One particular course had a wide range of tasks that included group and individual projects as well as oral presentations. Few courses required practical application exercises; however, with the majority of statistical analysis tasks being in the form of canned or directed tasks. The textbooks used in these courses were examined. The following titles were utilized:

- *Publication Manual of the American Psychological Association*
- *Scientific Research in Education*
- *Statistical Reasoning for the Behavioral Sciences*
- *Design and Analysis of Experiments*
- *Experimental Design and Analysis*
- *ANOVA Repeated Measures*
- *Practical Research: Planning and Design*
- *Educational Research – Competencies for Analysis and Applications*
- *Exploring Research Methods with an Aviation Emphasis: A Student Guide*
- *Writing Empirical Research Reports: A Basic Guide for Students of the Social and Behavioral Sciences*
- *How to Use SPSS: A Step-by-Step Guide to Analysis and Interpretations.*

Undoubtedly, the titles indicated a much more focused and in-depth exploration of research methods including computer-assisted quantitative analysis. Yet, even some of these resources gave only cursory or introductory exposure to certain topics.

Interviews of Aviation Program Directors/Faculty. Interviews with 11 aviation program directors and faculty members were completed over a six-week period. The results were organized as pertaining to undergraduate or graduate education and interview question. Next, responses were analyzed using content analysis to identify common themes.

***Interviews of undergraduate aviation program directors/faculty*.** Responses by undergraduate aviation program directors and faculty were analyzed. Content analysis was used to identify common themes for each interview question.

The question of "How do you (or your institution) teach research methods/skills to students." Only one program identified that they had a dedicated research course. Within this class students were introduced to mostly quantitative methods with a focus on statistics and related research methods. The remaining programs had no specific research methods or research focused courses. The theme among programs was that only basic research skills were covered or required such as the performance of library research, general writing skills, reading literature reviews, how to avoid plagiarism, but "no new knowledge" was produced. Some limited exposure to research design and statistics were garnered through the aforementioned activities. The most common research task oriented coursework was a form of senior capstone class that generally involved some sort of project that had to be reported upon in written and/or oral formats. Coursework was industry rather than research focused.

The question of "What types of research skills do students have to use in such courses." The research skills provided to undergraduate students was limited to writing research papers, performing internet searches, case studies, legal research, and limited data analysis (using Department of Transportation databases). Other types of research that students were exposed to included accident reports, qualitative assessments, financial documents, and legal cases. One class actually did bring in librarians to explain how to use research databases and the basics of APA format and style. A limited introduction to problem statements, writing literature reviews, basic statistics (e.g. chi square, *t*-tests, & correlation), and central measures were provided by one of the analyzed undergraduate programs. Some discussion of research quality and evaluation was provided in two of the courses. Lastly, limited coverage of methodological types was provided in one course.

The question of "What types of projects or assignments are given in such courses."Assignments in undergraduate courses revolved around writing. Papers ranging from 10 to 50 pages were typical and generally required a review of literature. Additionally, capstone projects with more practical implications rather than research focus were common. Powerpoint presentations of either the paper or capstone results were omnipresent. All projects were more industry or instructor driven rather than student or research driven. A limited amount of critiquing and critical thinking were required of students. Lastly, proposal writing was present in half of all cases reviewed.

The questions of "Do you feel that students are competent researchers following completion of the course(s)? Why or why not? What could be done to change this (if applicable)." Answers to this question were almost all no, except for two. One stated that students were "competent for that level [*undergraduate*] of project" while another said, "yes, they are competent to enter industry." Other comments included that students graduate "with basic research skills" and that they "probably can find things or facts." Another stated that students should be comfortable gaining institutional review board approval. One respondent noted that students were not competent to go on to graduate school but were skilled enough to function in airline operations such as in the role of a pilot.

All individuals noted that more research education was needed at the undergraduate level, in particular earlier in the curriculum. Another theme identified was to allow for more student driven skill building. There was a variety of other recommendations included in comments including need for more writing courses, inclusion of statistics, more instruction on data analysis, and requirements for more complex projects.

The question of "What artifacts are collected." The types of artifacts that were collected were papers, presentations, and capstone projects. Papers ranged from 10 to 50 pages. Presentations were required to be conducted in front of groups of peers, faculty, and/or industry stakeholders. All items were frequently amassed for assessment purposes.

The question of "What are the weaknesses of students that you commonly see in these courses." There were a wide range of weaknesses identified but the most common were poor writing skills and the conduct of plagiarism. Other comments included:

- Not aware of "what research really is"
- Unfamiliar with scientific method
- Preference for quantitative methods (misunderstanding of qualitative methods)
- Finding legitimate sources rather than performing Google searches (e.g., use of Wikipedia)
- Lack of citation skills
- Poor APA skills
- Unable to construct research questions

- Inability to identify research problem.

The question of "What are the strengths of students that you commonly see in these courses." The most frequently identified strength of students was their comfort with using technology. Internet search skill was noted to be very good with a strong ability to find source material. Other strengths included:

- Competent aviation industry knowledge
- Time management skills
- Good presenters
- "Thinking outside the box"
- "Want[ing] to write better"
- "Appreciation for written and oral communication."

Interviews of graduate aviation program directors/faculty. Responses by graduate aviation program directors and faculty were analyzed. Content analysis was used to identify common themes for each interview question.

The question of "How do you (or your institution) teach research methods/skills to students." Graduate students received more directed and detailed research instruction. Introduction to statistical methods was universal as was coverage of qualitative and quantitative designs. Guided readings and research were most common with little "actual research" being conducted except at the doctoral level. SPSS and other types of software were mentioned in two courses. APA formatting and style were covered in a majority of courses and were expected to master in all evaluated programs. The most detailed instruction occurred at the doctoral level with 12 to 15 credit hours focused specifically on methods, statistics, and design.

The question of "What types of research skills do students have to use in such courses." Graduate students received skill building guidance in proposal writing, conducting literature reviews, performing ethical research, dealing with IRBs, evaluating research quality and the use of a range of methods and designs. Doctoral level students received the most detailed instruction typically focusing on the particular method and analysis to be used in the study performed by the student. Statistical analysis instruction was widespread, though only doctoral level learners appeared to learn how to use more complex analyses (e.g. beyond t-tests, correlation, ANOVA, and non-parametric equivalents). Just as among the undergraduate programs, the majority of skill building resided in writing assignments.

The question of "What types of projects or assignments are given in such courses." Most assignments were significant writing tasks, namely a capstone project, thesis, or dissertation. Not all master's programs required a thesis per se with one program leaving an option for a comprehensive examination option.

The questions of "Do you feel that students are competent researchers following completion of the course(s)? Why or why not? What could be done to change this (if applicable)." There was a mixture of positive and negative sentiment about research competence. For master's students, two individuals stated that their graduates were competent researchers. Another stated, "60% are 40% are not." At the doctoral level, one stated that even such students were not entirely competent: "students are unfamiliar with studies and methods outside that used in their dissertation." All but one stated that students typically had a higher level of familiarity with qualitative methods than with quantitative. The need for students to have more statistical preparation was mentioned by all but one program stakeholder.

The question of "What artifacts are collected." Projects, theses, and dissertations all serve as evidence of competence and completion. These milestones were often used to trace tasks back to learning and program outcomes for assessment purposes.

The question of "What are the weaknesses of students that you commonly see in these courses." Three major themes emerged from the weaknesses mentioned during the interviews. First was a general debility in statistical knowledge. There were several comments concerning the lack of statistical backgrounds among graduate students. Second, there was a unanimous recognition that student writing was anemic. Third, a deficiency is knowledge of research methods was recognized. Other weaknesses mentioned were:

- Inability to differentiate between "prove" and "statistical significance"
- Poor logic
- Improper or flawed use of references
- Incomplete literature reviews
- Bias towards quantitative methods
- Lack of mathematical preparation
- Problems handling data analysis/improper data analysis
- APA style/format errors.

The question of "What are the strengths of students that you commonly see in these courses." Two primary themes became apparent from the results of the interviews. One was the recognition that graduate students were "tech savvy" – they are comfortable with online instruction, databases, and various computer technologies. Another was that student largely had a good understand of the aviation industry and were knowledgeable about the subject area of their thesis, capstone, or dissertation. Other strengths included:

- Confidence
- Autonomy
- Persistence.

Discussion

This study sought to assess and analyze the current non-engineering aviation research methods and skills education landscape in order to provide an improved understanding of this realm. Throughout the data, a common refrain existed: aviation research education, particularly at the undergraduate level, was in need of strengthening and improvement. Even among graduate programs, deficiencies in student competence in research methods was noted. This is particularly troubling as the literature noted that such lack of skills have a trickle-down effect on the quality and quantity of research studies conducted in a particular subject area.

With only slightly more than a third of programs having research-specific courses and less than 5% having such courses specifically focused on aviation, it should be no surprise that undergraduates are not exposed to the research skills needed to go on to graduate school or conduct “real” research in the field. Although things appeared to be better among graduate programs with a near majority of having research oriented courses, less than half had aviation focused research courses. Although general research skill building is helpful, there are certain aspects unique to the aviation industry that would benefit from more directed coursework.

Findings for Undergraduate Courses. Undergraduate aviation research education appeared to concentrate on introductory and cursory treatments. Although there were many mentions of statistics, the coursework did not appear to be in-depth or comprehensive. Considering that all assignments in the research classes among these programs were instructor and industry driven, little, if any, engagement or immersion in research occurred. No collaboration with faculty appeared to exist and students were not readily recruited to assist in actual research projects being conducted at the participating institutions. As noted by Healy, Jordan, Pell, and Short (2010) and LaBeouf (2011), the lack of *research-led* philosophies was likely one of the primary reasons why graduates were not considered to be competent researchers and why entrants to graduate school have been determined to have deficient preparation for the rigor of such programs. Although the course descriptions indicated that a broad spectrum of research oriented subjects were covered, the premise of this education seemed to revolve around primer material and writing rather than performance and practice. Little attention was given to APA protocol, style, and format commonly used in aviation research. This paucity clearly has caused issues as students migrate up to the graduate level. As described by España (2004), undergraduate aviation research education does not go beyond the dualism phase. Without exposure to the skills and practice of conducting real-world research, students lack the building blocks mentioned by Pato and Pato (2001) to become capable researchers.

Program directors and faculty reinforced the contents uncovered in the course materials. Little or no coverage of research methods was provided and quantitative methods took precedence. Again, research education seemed preliminary, not preparatory and there was a dearth of application of what was taught. The term research seemed to be most equated to "looking things up" or "finding sources" rather than production of "new knowledge." Writing was the primary means of assessment even in light of the fact that deficient writing was a common complaint about student skill sets. The admission that students are not aware of the true nature of academic "research" and that there were issues concerning construction of research questions and defining research problems bodes poorly for producing competent student researchers. Another problem area, plagiarism, was prevalent and speaks to the need for improved education about paraphrasing, proper citation techniques, and formal writing proficiency. Undergraduate students are comfortable with technology and have a good sense of the aviation industry. These attributes should be used to help in the research education improvement process.

Findings for Graduate Courses. At the graduate level, the students were exposed to a more comprehensive variety of research subject matter. In-depth coverage or entire courses were dedicated to qualitative, quantitative, and/or mixed methods. There were more aviation-specific research courses allowing for a more focused inquiry into aerospace subjects. The number of different topics and methods covered were also much more varied with an even more quantitative direction. Instruction on and the use of more advanced statistical methods were customary. Analysis software, including SPSS and other data analysis software, received more coverage. Taking the building-block approach advocated by Pato and Pato (2010) even further, several programs had dedicated aviation research methods/design and statistics courses. Doctoral classes had the most advanced coursework with improved exposure to qualitative and alternative methods, experimental designs, and complex statistical analyses. The density and inclusiveness of subjects covered were clearly related by the mind map produced from the data of this study. Unfortunately, many of these courses measured mastery through tests, assignments, and papers rather than the conduct of practical research or collaboration with faculty and/or peers. This precedent is in direct contrast to the findings of Sullivan and Maxfield (2003) in that students are not being exposed to the research paradigm. Such exposure has been theorized to be necessary to gain the experience and comfort indispensable to become skilled scholars.

Interviews with stakeholders yielded similar results in terms of reported subject coverage. At all levels of graduate education there were some reservations made about claiming competence in research skills among students. Even in light of a strong bias towards quantitative methods, one major theme among weaknesses was that students still lacked a good understanding of statistics particularly in the application thereof. Writing ability was also noted as an infirmity. Further, knowledge and practice of research methods were identified as problematic, particularly once exiting a student's *comfort zone* (i.e., in areas outside the method(s) used in their capstone, thesis, or dissertation). Therefore, a range of learning was still necessary for graduating students to become proficient scholars. Basic deficiencies in research skills such as APA errors, inability to analyze data, and incomplete literature searches were also mentioned. In terms of strengths, graduate students exhibited high competence in the use of technology and were well versed in their particular area of interest within aviation.

Unique Findings. Although there were significant similarities among programs at all education levels, there were some exceptional cases that merit inclusion. One undergraduate program was introducing more research coursework to better support their senior capstone project. Due to the poor quality of student performance in this culminating course, the institution was in the process of adding a statistics application and research design class that was specifically aviation centered. One program had aspirations to have the best writing program in aviation. Students in this undergraduate program are exposed to research and writing in their first aviation course. Some of the tasks to which they are introduced included peer-reviewed research, annotated bibliographies, and writing skills. Students are required to turn in multiple drafts of papers, further, their papers are sent through plagiarism detection software. The final product must exceed a 12th grade reading level according to the Flesch-Kincaid readability index (an evaluative tool available in Microsoft Word). The culminating event is the senior capstone project that serves as an assessment of the research and writing threads that run through the program. The project must also be presented to a panel of major airline and industry executives as well as aviation-related government personnel. Furthermore, students participate in poster sessions in a manner similar to that advocated by Crull and Collins (2004). All of these activities provide some academic *socialization* necessary to become confident and competent researchers (Sullivan & Maxfield, 2003).

Conclusions

The consensus of data uncovered in this study indicated that aviation research education is still in a nascent phase. It is evident that undergraduate students have not been receiving the essential exposure to research methods and skills. The existing model relies on outside sources for research education; clearly, aviation programs lean too heavily on other departments such as English and math to teach the necessary expertise. The sentiment among faculty and program leadership favored a bolstering of research skill building throughout the undergraduate level additionally they stated a need for this activity to occur early on within the curriculum as what few encounters with research seem to currently take place in the senior year. Practical application also was lacking. It is difficult to surmise how students are to learn how to conduct research when they are only tasked with writing papers or taking exams. Faculty need to involve students in their research and encourage independent inquiry as early in a student's progression as possible.

Even graduate education is ostensibly in need of enhancement. This issue was undoubtedly related to the problems at the undergraduate level highlighted by the data. There was no evidence that instruction on quality, academic writing was given except for the limited feedback one may receive on a writing assignment. As is the case in many courses and programs, writing assignments are crowning events; therefore, little time remains to provide ample criticism. Much of the task loading lacks practical application and is highly instructor-lead. Students would benefit from a stepping-stone approach as they progress through a program with courses that not only convey subject matter but also require the exercising of gradually more complex research skills. Essentially, it seems as though goals of research dexterity improvement should exist in most if not all courses.

Lackluster writing and problems with plagiarism were both evident among all programs and at all levels. The cycle shared among programs was students were exposed to writing in English courses and through minor assignments in both aviation and non-aviation classes. Seemingly, students were expected to simply produce although little instruction or guidance was given on actually how to write well. Students were expected to construct a well-crafted piece of cogent and logical script but do not seem to be given the necessary tools to advance their talent. The cycle frequently ended with a large research project in a capstone or culmination course normally in the last two terms. Complaints about student performance in these courses points to the need for more instruction on research methods, writing, style, and format. Directive and practical application tasks should be added to make inroads towards improved writing. Related to this, of course, is plagiarism. Students are not being given the requisite education on how to paraphrase, summarize, and cite research material. Exacerbating this is the widespread use of the internet and electronic sources making *cut and paste* very tempting and easy to do. Unfortunately, this plagues later stages in a student's education and rears itself even at the capstone level. If left unchecked, this can (and has) trickled into graduate education or academia.

In summary, it is evident that students need to be exposed to research earlier, more frequently, and in further detail than what is currently occurring. Initiatives to help students become involved with research being conducted by faculty should not only be encouraged but should be required. Only by conducting real, relevant studies can student learn the skills necessary to become a successful scholar. A building-block approach would be the logical means of preparing students to conduct research. Of course, concentrated efforts must also develop firm writing skills. This requires exposure to the type of writing that is expected in the field meaning students must be immersed in the literature. Then they will need practice to assist in the transition from high school style writing to academic prose. Even an undergraduate who has no intention of going to graduate school would benefit from such edification. Few occupations have career ladders that do not entail some level of investigation or exploration optimized by the use of research skills and tools. Weakness in student research competence was a common and constant complaint among faculty and program directors. Nevertheless, it is unfair to mull over this predicament without recognizing the reason by such faults. Research education is a necessary component of all programs at all levels. Only through improvements can progress be expected towards graduating future scholars.

Recommendations for Future Research

These findings should be of interest to aviation program administrators to ensure that their programs are in line with the best practices being conducted at peer institutions. Faculty will also be able to use the findings to examine how their courses compare to those at other programs. In light of the conclusions and findings of this study the following recommendations for future research are suggested:

1. Conduct a study of student perceptions about research education to discover the learner’s perspective of this research problem.
2. Perform a study to identify best practices in research education. Possible methods include a Delphi panel, a blog, or focus groups.

3. Broaden the current study to provide a more comprehensive look at syllabi and faculty sentiments.
4. Survey graduates to see what research skills are being used on the job and the types of strengths and weaknesses that have been identified in workplace research.

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Appendix A

Participating Institutions: Interviews and Syllabi

- City University of New York (York College)
- Embry-Riddle Aeronautical University
- Florida Memorial University
- Lewis University
- Middle Tennessee State University
- Ohio State University
- Oklahoma State University
- Rocky Mountain College
- Saint Louis University
- University of Maryland Eastern Shore
- University of Western Ontario

Appendix B

Interview Protocol

Thank you for helping me by sharing your experiences in how research methods and skills are taught in aviation programs. This interview process does not have any known harmful effects. Benefits of the process include the potential improvement of the survey you received which will lead to a better understanding about aviation faculty. Your participation in this process is completely voluntary. By agreeing to complete this interview process, you are implying your consent to participate. Does this meet with your approval? Good.

Just as a reminder, I am taking records of our interview session. Following the interview I will email you a copy of this for your review. Is this acceptable to you? Thank you!
What I am interested in learning during this interview process is how research methods and skills are at your institution.

Please feel free to give me as much detail about your feelings, experiences, and suggestions as you are willing to offer. I am very much interested in your thoughts, ideas, and perspectives. Before we begin, do you have any questions? So you are ready to start?

1. How do you (or your institution) teach research methods/skills to students?
2. What types of research skills do students have to use in such courses?
3. What types of projects or assignments are given in such courses?
4. Do you feel that students are competent researchers following completion of the course(s)? Why or why not? What could be done to change this (if applicable)?
5. What artifacts are collected?
6. What are the weaknesses of students that you commonly see in these courses?
7. What are the strengths of students that you commonly see in these courses?

SECTION D

Embedding Inquiry-Based Learning Activities to Create a Research-Supportive Culture

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This paper references several sources the author researched as part of the development of FACD801 *Ignite Pedagogy Introduction*.

ABSTRACT

Research, in its most elemental form, is the process of asking a question and searching systematically for an answer. Thus, it is inquiry-based. Embedding inquiry-based activities throughout the curriculum facilitates the creation of a research-supportive culture, the stated purpose of Embry-Riddle Aeronautical University's Quality Enhancement Program. Inquiry-based activities range from confirmation of known principles following an instructor-specified procedure, to independent formulation of questions and investigative procedures by the students themselves. They follow inductive methods and constructivist principles. Instructor preparation requires careful planning, with attention to learning objectives, resources required, and student resistance factors. Instructors must possess deep content knowledge and a variety of pedagogical strategies. Often the greatest challenges are embracing cognitive dissonance and handling unexpected or nonexistent student responses.

Introduction

Why is the sky blue?

What happens when we die?

How come the other kids don't like me?

Probably most people would not instinctively recognize these as research questions, and yet they are. In its most elemental form, research is the process of asking a question and then searching for an answer. From this standpoint, research activities are inquiry-based; everything starts with a question, and questions continue to guide the work throughout the research process.

To define research as fundamentally inquiry-based leads to an important clarification: There are many ways to search for answers to the research question; however, the method used does not determine whether or not research is being conducted.

Of course, children just ask the question and wait for someone to provide an answer; however, from an academic perspective, research is a bit more organized than that. Embry-Riddle Aeronautical University's Quality Enhancement Plan (QEP) *Ignite* (Embry-Riddle Aeronautical University, 2012) defines research as "a systematic inquiry or investigation" (p. 7). Inquiry-based learning meets the systematic criterion; it utilizes inductive teaching methods. It is with this understanding of research as beginning with and guided by questions and conducted in a systematic way, that inquiry-based learning is presented as a potent means of accomplishing the stated purpose of *Ignite*: to establish "a research-supportive culture in the undergraduate community" (p. 7).

Inductive vs. Deductive Teaching Methods

Inductive teaching methods begin with a specific problem or question and students learn, as they work along, the general principles and skills they need to know in order to solve the problem or answer the question. In traditional deductive teaching methods, by contrast, learning proceeds from the general to the specific. Students first learn relevant theories and processes and then apply them to solve particular problems or answer specific questions.

To present a simple example of the differences, Table 1 shows the contrast between inductive and deductive teaching approaches when the objective is to produce an effective oral presentation, a common assignment in many courses. In the deductive approach, the instructor would provide a list of the general characteristics of an effective oral presentation; for example, it is organized and focused; employs clear, precise language; and is supported by appropriate visual aids. Students and instructor would discuss each of these in turn, ensuring that the characteristics were effectively defined. Students might then expand their understanding by viewing oral presentations and analyzing them. Finally, students would be given the task of producing their own oral presentations, to demonstrate that they can apply the general principles to a particular task.

In contrast, using the inductive approach, the instructor would assign the task at the beginning and send the students off to prepare their oral presentations. In the process, students would discover on their own the characteristics that they believe are necessary in an effective presentation and incorporate them into their plans. There are many possible ways that they might make these discoveries: through brainstorming, by recalling presentations they enjoyed and those they didn’t, or by doing research. When the students make their presentations, the instructor would guide the discussion and analysis, so that students could draw out from their own experiences the general characteristics of an effective presentation.

Table 1

Contrasts in Deductive and Inductive Approaches to Teaching

Objective: Produce an Effective Oral Presentation	
Deductive Approach	Inductive Approach
1. The instructor provides information (general characteristics of an effective presentation) and ensures that students understand each characteristic	1. Instructor provides basic information (time limit, for example) and gives the assignment (produce an effective oral presentation).
2. Students expand their understanding (write reports about famous presentations; analyze examples of effective and ineffective presentations; complete textbook exercises such as quizzes).	2. Students prepare their presentations. In the process, they discover that they need information that was not given in the assignment; they don't know what the characteristics of an effective oral presentation are. They determine how to get the necessary information; they get it and apply it.
3. Instructor gives the assignment: students apply their general conceptual knowledge to demonstrate mastery (produce an effective oral presentation).	3. Students make their presentations; they and the instructor discuss their experiences. The instructor has students describe their processes, including any problems they had and how they solved them. During the discussion, the instructor encourages students to recognize the general concepts at work, using their particular experiences as reference points.

In "The Many Faces of Inductive Teaching and Learning," Prince and Felder (2007) offer this definition of inquiry-based learning:

> Any instruction that begins with a challenge for which the required knowledge has not been previously provided technically qualifies as inquiry-based learning, and the scope of

> the inquiry may vary from a portion of a single lecture to a major term project. In this sense, all inductive methods are variants of inquiry, differing essentially in the nature of the challenge and the type and degree of support provided by the instructor. (p. 15)

Prince and Felder (2007) discuss various specific types of inquiry-based learning, including most of them under the rubric of discovery learning. Pure discovery learning is not usually found in undergraduate programs, because it typically involves little or no guidance beforehand from the instructor. It is more common to find some variation of guided discovery, such as problem-based learning, project-based learning, case-based teaching, and hybrids of these types.

What all these forms have in common is that students begin the process without being given everything they need to know. As they work through the process, they identify what they need to learn—knowledge they do not already possess that is required for them to proceed toward a solution; they determine how to acquire that knowledge; they acquire it and apply it and move forward. The differences in the types lie mainly in how much help students receive in the beginning and throughout the process.

It should be clear, then, that embedding inquiry-based learning activities throughout the curriculum does not mean that every course must include a formal research study. Because inquiry-based learning is essentially a structured method of investigation, the inquiry process can be adapted to accommodate increasing levels of responsibility and autonomy. Ketpichainarong, Panijpan and Ruenwongsa (2010) describe the trajectory toward independent learning as having four levels:

> Level one is confirmation; students confirm a principle through activities in which the results are known. Level two is structured inquiry; students investigate questions using

> the procedure provided by the teacher. Level three is guided inquiry; students investigate teacher's questions by designing their own procedure. Finally, level four is open inquiry; students investigate questions related to learning topics by selecting questions and designing procedures by themselves. (pp. 171-172)

The Characteristics of an Inquiry-Based Learning Activity

Inoue and Buczynski (2011) provide an excellent overview of the characteristics of an inquiry-based activity:

> In order to deliver an effective inquiry lesson, a set of general principles typically suggested in pedagogy textbooks are (a) to start the lesson from a meaningful formulation of a problem or question that is relevant to students' interests and everyday experiences; (b) to ask open-ended questions, thus providing students with an opportunity to blend new knowledge with their prior knowledge; (c) to guide students to decide what answers are best by giving priority to evidence in responding to their questions; (d) to promote exchanges of different perspectives while encouraging students to formulate explanations from evidence; and (e) to provide opportunities for learners to connect explanations to conceptual understanding. (p. 10)

Many instructors may recognize that they are already using one or more of these principles in their classrooms. They may already be assigning case studies, problems or challenges that are real-world focused and represent situations that students could likely grapple with during their careers. Thus, they are fulfilling the first general principle: starting the lesson from a meaningful formulation of a problem or question that is relevant to students' interests and everyday experiences.

However, an effective inquiry-based lesson can begin at a much lower level than assigning a case or a problem. Any part of the oral presentation challenge could have been the basis for a simpler inquiry-based activity. For example, the instructor could have focused on visual aids and asked students to bring to class various types of aids, such as photographs, diagrams, or charts. Then the instructor could have asked students to discuss the strengths and weaknesses of the various aids. This exercise would have led to students' discovering some general principles, such as the importance of size and the need to avoid distortion of data in graphical form.

This exercise described above shows how the second principle, asking open-ended questions (what are the strengths and weaknesses of each aid?) and providing students with an opportunity to blend new knowledge with their prior knowledge, can be useful in devising a level-two (structured inquiry) activity.

Open-ended questions invite students into the process of constructing knowledge. These kinds of questions ask, "How?" or "Why?" They ask about possible causes or potential consequences. They invite conjecture, imagination, and invention. This free-form speculation is essential; however, in addition to being grounded by its connection to previous knowledge, as the process proceeds, the options for answers and solutions must also be weighed against evidence. This is the third principle: Guide students to decide what answers are best by giving priority to evidence in responding to their questions.

The emphasis on evidence reveals the roots of inquiry-based learning in the scientific disciplines:

> The National Science Education Standard (NRC, 2000) identifies five necessary components of inquiry based teaching and learning: student engages in scientifically

> oriented questions, student gives priority to evidence in responding to questions, student formulates explanations from evidence, student connects explanations to scientific knowledge, and student communicates and justifies explanations. (Ketpichainarong et al., 2010, p. 171)

Remove the specific references to *science*, and it becomes apparent that the process can be adapted across disciplines. In literature courses, for example, the 'evidence' necessary is provided by the source document, such as a short story, poem, essay or novel. In engineering courses, the 'evidence' may come in the form of decision sheets or data sets (Friedman, Crews, Caicedo, Besley, Weinberg, & Freeman, 2010).

Students may chafe at the instructor's insistence on evidence-based analysis; however, to paraphrase French essayist Joseph Joubert (n.d.), to have imagination without evidence is to have wings but no feet. It's fun to fly (as Embry-Riddle Aeronautical University students know), but sooner or later, one has to land. This is not to diminish the value of flights of fancy. The fourth general principle of inquiry-based learning is to promote exchanges of different perspectives while encouraging students to formulate explanations from evidence.

At this point, it becomes a critical skill to be able to evaluate evidence accurately. Common criteria for evaluation of evidence include reliability (accuracy), angle of vision, degree of advocacy (bias), and credibility (Ramage, Bean & Johnson, 2012). Credibility in particular, can pose problems. Instructors often guide students toward scholarly sources, in an attempt to help them employ credible evidence; yet the truth is that students will find many types of evidence and must learn to examine the information carefully, even when it is presented by what they perceive as authoritative sources.

In “The Economy of Explicit Instruction,” Kramer (2007) makes the point that unquestioning acceptance of information can easily arise from the wording used to present it, citing the ways facts are referred to as if there were only one interpretation and pointing out how some words, such as *data*, seem to invite automatic confidence. He writes:

> These metaphors … reinforce the belief that facts are proof—for *everyone*, hence the emphasis on discovery rather than on interpretation. This emphasis has consequences: rendering irrelevant the questions of who looks; of whether there might be more than one way to see; of whether there might be more than one way to interpret what is seen, even for the one person who is seeing …. (p. 103).

Ellen Langer, whose research focuses on the effects of assumptions on perception, makes the strong point that “research only gives us probabilities and we transform those probabilities into absolute facts,” but when unconscious assumptions are challenged, people “begin to see how situated and contextual what we accept as facts actually are” (as cited in Rhem, 2012).

Rhetorical analysis of texts in almost any discipline (mission statements, action plans, reports of all types, histories, analyses) can be inquiry-based learning activities. At the level of confirmation, the instructor might take students through an exercise in which they note their reactions or responses to certain words or phrases, after which they could discuss them and the instructor would use their specific responses to clarify the persuasive power of word choices, a key principle of rhetoric that can be used to determine the degree of advocacy in text. At the level of structured inquiry, the instructor would provide a procedure for students to follow on their own; for example, asking students to determine the degree of advocacy in a text by answering a series of questions. At the level of guided inquiry, the instructor would challenge students to determine the degree of advocacy, and the students would devise their own procedures. At the level of open-inquiry, students would select their own questions related to the topic of rhetorical analysis; for example, they might want to investigate how rhetorical analysis may have changed over a certain time period or been influenced by a certain event. Then they design the investigative procedures themselves.

The final principle that describes an inquiry-based activity is the provision of opportunities for learners to connect explanations to conceptual understanding. This is the inductive step of going from the specific to the general, from the concrete to the abstract. This is the place in the process where knowledge and skill transfer is to be achieved, so that students can apply what they have learned to other problems in other situations. In student-centered learning, which all methods of inquiry are, the goal is for the students to make these connections themselves, with less and less guidance from the instructor as their proficiency increases.

Instructor Preparation

These are the general guidelines, then, that describe an inquiry-based activity:

- Make the lesson relevant.
- Help students graft new knowledge onto old.
- Give priority to evidence when evaluating possible answers or solutions.
- Encourage the free exchange of ideas.
- Enable students to make the leap from the concrete to the abstract.

When the characteristics are thus simply stated, they might be deceptive. Designing and implementing an inquiry-based activity demands time and effort, and it entails risk. Still, instructors can maximize the chance of a successful activity with careful planning. Having noted earlier that there are many ways to incorporate inquiry-based learning into a course, the first decision usually concerns the type of inquiry-based activity to use. In determining this, Prince and Felder (2007) suggest that instructors direct their thinking in three areas: the learning objectives, the resources required (including the instructor's time, experience and comfort level), and possible student resistance.

Learning objectives. Like everyone else, students want to understand why they are doing what they are doing. If the connection to course goals or learning outcomes is not clear, instructors must explain it to them. This does not have to happen before the activity is undertaken; in fact, using the inquiry-based learning approach, instructors would refrain from providing too much explanation at the start. However, instructors will find it very useful to make the connections explicit for them, in the creation stage of the activity.

A curriculum design process known as backwards design actually begins with the instructor specifying the learning objective. The instructor then decides how students will demonstrate achievement of the objective, the evidence they will produce. From there, the instructor devises the means by which students will learn the knowledge and gain the skills required to demonstrate this achievement (Graff, 2011).

This backwards design process can be used for an entire curriculum, an entire course, or a single lesson. For the purpose of demonstration, the focus will be on a single lesson.

A simple way to engage in backwards design is to create a diagram or an outline. For example, as mentioned earlier, a common assignment in many courses is an oral presentation. An outline for this activity would detail each step, along with any built-in obstacles that students will have to overcome. Figure 1 shows a possible outline for this activity.

Learning Objective: Students demonstrate understanding of the characteristics of an effective oral presentation

Inquiry-based learning activity: Producing an oral presentation

Activity steps:

1. Provide the basic information (time limit) and give the assignment (produce an effective oral presentation).

2. Have students prepare their presentations
   a. Planned problem area: students do not have a list of these characteristics (organized, focused, clear language, visual aids)
   b. Possible solutions: students brainstorm their own list; students look up information online; students base their plans on presentations they liked

3. Students make their presentations; discuss the experience, drawing out the concepts students must learn (learning objective) and helping them link the particular experience to the concepts

Figure 1: Outline of inquiry-based exercise in producing an effective oral presentation

In the planning stage, the major value of an outline is that it helps instructors think through every aspect of the planned activity. It helps instructors see if they've made any leaps in logic, missed anything important or gotten off track somehow. And it reminds instructors to ensure that students see the linkages between what they have been asked to do and what they are expected to learn. This is especially important when the activity does not obviously connect to the course content.

As is evident, the strategy of 'starting at the end' includes a decision about how to assess the success of the activity. Madden (2010) describes one of the hidden pitfalls here. Inquiry-based learning activities encourage students to generate their own answers and solutions, but instructors must be able to evaluate them. This often necessitates that the instructor create a model answer or solution, as is specified in *2.a.* in Figure 1. The temptation then can be to evaluate the students' work, based on how congruent their results might or might not have been with the instructor's model.

An outline can keep an instructor from falling into this trap, primarily by keeping the learning objective in the forefront of the exercise. For example, in the presentation exercise, it could seem that the desired evidential outcome would be an engaging, interesting presentation. However, that is not the case. Students' efforts might produce presentations that are bland or boring, and yet their analyses (in Step 3) might reveal excellent comprehension of the characteristics of an effective oral presentation, the true goal of the exercise.

Subject matter content, of course, must be learned. Critics of inquiry-based learning worry that content knowledge is given short shrift in the service of mastering the process. Defenders counter that knowledge is learned more effectively. In addition, by learning how to learn, students are better able to transfer knowledge and skills from one area to another (Friedman et al., 2010; Justice, Rice, Roy, Hudspith, & Jenkins, 2009).

Resources required. There is much to think about when considering the resources that will be required for the chosen activity. Perhaps the first question that comes to mind concerns the kinds of raw materials needed. Are the challenges pre-written or must the instructor create them? Are facilities such as labs available? Is the classroom space appropriate?

Prince and Felder (2007) compare the instructional demands of various types of inductive teaching methods, showing required resources, planning time and instructor involvement, and student resistance. The range in demands on instructor time and involvement is great, from small demands when using existing cases and individual projects; through moderate demands for just-in-time teaching, which requires the instructor to tailor the lesson plan to accommodate gaps in knowledge indicated in students' responses to pre-class questions on content; to considerable demands for team projects and cases. There’s a fourth level, extensive demands on instructor time and involvement, reserved for original problems.

These are the kinds of concrete questions anyone might think to consider when designing a class activity. However, another important factor in a successful inquiry-based activity is the social atmosphere in the classroom or online environment. Inoue and Buczynski (2011) say that “preparing a non-traditional lesson requires the teacher to predict the possibilities of classroom interactions and carefully consider ways to shape the social norms of the classroom to facilitate student-centered thinking” (p. 11). This can be a challenge, especially at the beginning of a course when the classroom climate is still unknown.

As instructors consider ways to shape the learning environment, they should carefully examine their own attitudes and expectations. The instructor’s teaching philosophy has to be compatible with the constructivist underpinnings of the inquiry-based approach (Justice et al., 2009). Inoue and Buczynski (2011) cite research showing that novice instructors, even those who get training in inquiry-based instruction, often believe that student-constructed knowledge is inferior to that provided by the instructor.

Veteran instructors may encounter difficulties, as well. Justice et al. (2009) note that some very well respected, excellent instructors may feel devalued if they are preached to about the superiority of inquiry-based methods, a circumstance that often accompanies the adoption of a new concept, approach or practice in an institution. The authors also point out that other attitudes, even subtly held, can have profound effects; for example, viewing inquiry-based learning as a passing fad, considering it irrelevant to the higher purposes of a university education, and expecting that students have already developed the skills before entering their classes.

Even instructors who want to avoid being *the sage on the stage* may find it is no easy task to re-orient students' perceptions of their authority. Gerson and Bateman (2010) define four types of authority that instructors have: institutional authority that is theirs by reason of their appointments as instructors, content area authority, authority conferred by expertise in the subject area, and "performative" (p. 200) authority, which arises from their successful engagement with students.

An instructor cannot simply lay aside these various mantles, even if that is the instructor's wish. However, the authors point out that the varying types of authority can exert greater or lesser influence; that is, both instructors and students can deliberately choose to emphasize one type over another. Therefore, although precisely equally shared authority may not occur, some type of very useful shared authority can be brought to bear in the service of inquiry-based learning.

As noted in the outline discussion, one benefit is that the instructor thinks through the activity, including the planned problem area and possible solutions. This takes time, of course, but instructors may be accustomed to investing time in the planning stage. However, many challenges can arise in the implementation phase that can sabotage the goal of the activity by eating up time. The open-ended aspect of inquiry-based learning means that students' creative responses can be unexpected, and instructors run the risk of undoing all their efforts if they do not respond in ways that encourage continued inquiry.

Three qualities that will help instructors avoid traps as they conduct inquiry-based activities are patience, depth of content knowledge, and a variety of pedagogical strategies

Patience is perhaps the primary virtue. A key component of the constructivist approach is cognitive dissonance, an intellectual tension—usually uncomfortable—that propels students to discover new ways to put information together to make sense of the information and decide the next steps toward finding a solution, arriving at an answer or achieving a goal (Ketpichainarong et al., 2010).

Inoue and Buczynski (2011) point out two common temptations that instructors must resist: jumping in with an answer when there are no responses and rejecting a student's response when it is off target. Both actions exert the teacher's authority and take the responsibility for learning away from the student. In particular, rejecting a student's off-target response can derail an otherwise well-constructed inquiry lesson.

An off-target response should be seen as an attempt by the student to construct knowledge by connecting new information to old (Inoue & Buczynski, 2011). This is a key concept in inquiry-based learning. The instructor's role is to try to facilitate that connection. Instructors should seek clarification of the student's thinking, while avoiding leading questions if possible. Inoue and Buczynski (2011) caution, "In inquiry based lessons, students develop, carry out, and reflect on their own multiple solution strategies to arrive at a correct answer that makes sense to them" (p. 10). They stress that it is important to allow students to share their answers, responses and/or solutions and to find ways to validate them, while still guiding students toward evidence-based outcomes.

This ability to validate and redirect requires both a depth of content knowledge and a variety of pedagogical techniques (Friedman et al., 2010; Inoue & Buczynski, 2011; Ketpichainarong et al., 2010). Instructors can run into trouble if they do not know how to explain concepts in different ways, if their content knowledge is not deep enough or their pedagogical techniques are not varied enough so that they have other avenues of expression to try if their first efforts do not succeed.

So how do instructors prepare for the moment when their brilliantly planned exercise goes off course? Certainly they can try to consider a range of possible responses during the preparation phase, but it is realistically impossible to think of every potential response. Getting feedback from peers often helps, but when the teachable moment turns out to be completely unlike the vision that inspired it, sometimes the best course of action might be to say, “I’ve never thought of it that way!”

Constructivist learning involves everyone, and the instructor who encloses himself or herself within the circle of learners can enhance rather than damage credibility. The unexpected development presents an opportunity for the instructor to affirm that students are true partners and collaborators, not “mere executors of processes predefined by authority” (Gilardi & Lozza, 2009, p. 254).

In the presence of the unexpected, many opportunities for learning arise. However, taking advantage of those opportunities requires that everyone in the room be able to remain in the uncomfortable presence of uncertainty, rather than take refuge in automatic conditioning. When students and instructor alike have stepped into the unknown, they have the chance to experience what Rhem (2012) calls “real learning [which] is always a shared inquiry, not a top down delivery of information.”

Student resistance. The final area of consideration concerns possible student resistance to the inquiry-based process. Understanding the source of the resistance is the key to defusing it. Ketpichainarong et al. (2010) call this learning to inspire at the right moment.

The right moment could be at the beginning of the inquiry-based activity. Savery (2006) advises that instructors clearly outline the process to be used and get the students’ commitment to it. For example, suppose that in an ethics course, the instructor wants to discuss a highly emotionally charged, controversial issue. The instructor could clearly state the rules for discussion; for example, one person speaks at a time and for no more than three minutes; no inflammatory or otherwise inappropriate language may be used; speakers must keep the discussion focused on the topic and avoid personal attacks. However, it would be even more effective for the instructor and the students together to formulate the rules and agree upon them, thus creating a rubric together. "Rubrics are used to incorporate students in the process to further support student knowledge and problem solving" (Friedman et al., 2010, p. 770).

At other times, resistance could arise from different learning styles. Based on student responses to surveys after her history of economic thought course, Madden (2010) suggests that students who prefer to think in concrete terms and want facts and knowledge delivery may have trouble with inquiry-based methods and need additional support from the instructor. She notes that such students "could benefit by exercises highlighting uncertainty in human knowledge" (2010, Synopsis and lessons learned, para 3).

Resistance can also arise from course content, for example, when students are challenged to examine their value systems or status in society. Mthethwa-Sommers (2010) describes the effects of the inquiry process on students in a Foundations of Education course that addresses issues of social injustice and discrimination in the educational system:

> The findings showed that through the inquiry-based method of teaching and learning, 47 out of 50 students were able to re-examine and transform their previous knowledge on certain diversity topics.... Such readjustments were critical in the reduction of resistance and were possible because the inquiry-based method positioned students as owners of knowledge. (p. 62)

Perhaps Prince and Felder (2007) provide the most helpful summary. In their analysis, they rank student resistance from minimal to major and say the highest level "follows both from the burden of responsibility for their own learning placed on students and the additional demands imposed by cooperative learning" (p. 17).

Instructors can diffuse resistance by building students' confidence in the instructors' ability to handle classroom dynamics including unexpected responses, take in account various social and cultural factors, link subject matter to students' experiences, and present knowledge in different ways (Friedman et al., 2010; Inoue & Buczynski, 2011; Ketpichainarong et al., 2010). They can also inspire confidence with well-developed lesson plans (Savery, 2006) and comfort with cognitive dissonance, including their own (Ketpichainarong et al., 2010).

Conclusion

Inquiry-based learning activities have been shown to improve student achievement in many types of courses: biotechnology (Ketpichainarong et al., 2010); educational technology (Ma, Xiao, Wei, & Yang, 2011); writing (Radhakrishnan, Schimmack, & Lam, 2011); philosophy, business and technology education, public health, engineering, social work (Friedman et al., 2010); economics (Madden, 2010). Inquiry-based learning also seems well positioned to help students develop their professional identities (Gilardi & Lozza, 2009). (Readers who are interested in learning about specific activities in courses or programs are encouraged to read some of the references cited at the end of the paper, particularly Friedman et al., 2010).

In addition, student responses to inquiry-based learning have been quite positive: (Friedman et al., 2010; Justice et al., 2009); Ketpichainarong et al., 2010; Ma et al., 2011; Madden, 2010; Summerlee & Murray, 2010).

The infusion of inquiry-based learning activities into most Embry-Riddle Aeronautical University courses is not only possible but, given the broad definition of such activities, likely also a simpler process than many might fear. Perhaps it would be useful to employ the succinct process description that was settled on by an interdisciplinary group of instructors at the University of South Carolina, who were charged with developing inquiry-based learning activities across the curriculum. They described five stages of an iterative cycle: “ask, investigate, create, discuss, and reflect” (Friedman et al., 2010, p. 768). This cycle encompasses the general guidelines that describe an inquiry- based activity that were described earlier:

- Ask (a relevant question).
- Investigate (helping students graft new knowledge onto old.
- Create (possible answers or solutions from the evidence).
- Discuss (incorporating the free exchange of ideas).
- Reflect (make the leap from concrete to abstract).

As noted, however, embedding inquiry-based learning activities into courses will not be without challenges. Yet every inquiry-based learning activity that is incorporated into a course helps to create the solid research-supportive culture demanded in *Ignite* and facilitates the desired transformative effect of quality enhancement required by the Southern Association of Colleges and Schools (SACS).

Moreover, the University desires this transformative effect over and above whatever SACS might require, for the good of its students. While it is expected that Embry-Riddle Aeronautical University students will become proficient in the various traditional methods of research, a more fundamental way to express the *Ignite* research goal is to expect to develop in each student a curious and highly skilled investigative mind, the type of mind that will significantly increase the preparedness of students for personal fulfillment and career success.

Although this paper has covered many characteristics of inquiry-based learning and attempted to provide an indication of how instructors can successfully prepare and conduct inquiry-based activities in their classes, at bottom it might help to remember that inquiry is a natural way of learning. It relies on one of the most fundamental characteristics of human beings: curiosity. “Inquiry as a teaching method seeks to develop inquirers and to use curiosity, the urge to explore and to understand, as motivators leading to learning through personal engagement” (Justice et al., 2009, p. 843).

In the case of inquiry-based learning, it is true, as many have said in other venues: “It’s so easy, even a child can do it!”

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SECTION E

AIRSPEED MEASUREMENTS

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ABSTRACT

This paper presents the results of a research project initiated as part of an ASCI 309 EV Home-Aerodynamics class held on Tuesday evenings during the 11/W1 term. The objective was to measure the airspeed of an automobile using techniques commonly used to measure the airspeed of light aircraft. The outcome of the recently completed project can form the basis for a research project for the next ASCI 309, ASCI 310, ASCI 509, or ASCI 510 course. It should be noted that use is made of material presented in the prerequisite courses: Math 112-Calculus (partial derivatives of multivariate functions), Math 211-Statistics (calculations of the mean and variance), and Phys 102-Physics (Conservation of Energy, Fluid Mechanics, and unit conversions) which lets the student consolidate and apply previously unrelated knowledge.

Introduction

The single most important piece of information a pilot can have is an accurate measurement of his airspeed. This information allows the pilot to make control adjustments and estimation for fuel reserves and destination arrival time. Measuring the airspeed is not a trivial exercise. The airspeed is measured indirectly by measuring the free-stream dynamic pressure, q_∞, the free-stream static pressure at altitude, p_∞, and the free-stream static temperature, T_∞, at altitude.

The purpose was to have students measure airspeed, while providing hands-on appreciation for actual measurement procedures; thus, providing guidance in both experimental procedure and analysis, and report formatting of experimental results.

Background

Embry-Riddle recently announced a program to encourage undergraduate research. The projected student outcomes are to:

Define a research problem

Conduct a literature search

Design a course of action

Identify a research method

Evaluate and apply information

Analyze

Reach a conclusion

Communicate results

In concert with this objective, students enrolled in ASCI 309 EVH, Oct-Dec 2011 on Tuesday evenings, were assigned the task of measuring the airspeed of an automobile - since wind tunnels are not widely available and few in the class were pilots.

The original purpose of this paper was to convey to the students my experience in performing this experiment, give them some guidance in the desired report format, and hopefully help them avoid some experimental pitfalls.

The technique commonly used to measure the airspeed of subsonic aircraft utilizes a Pitot-static tube located under the wing and is based on Bernoulli's equation. This instrumentation is usually calibrated at sea level and corrected for compressibility and density at altitude to obtain the true airspeed.

Method

The problem is to accurately measure the airspeed of an automobile using a technique similar to that used on low-speed aircraft. The technique is based on Bernoulli's equation which is the conservation of energy per unit volume for a flowing gas. $p_{static} + q = p_{total} =$ constant. p_{static} may be thought of as the potential energy; $q = \rho U^2/2$ = dynamic pressure which may be thought of as the kinetic energy; and p_{total} as the total energy, which is a constant, i.e. conserved. Solving the preceding equation for the airspeed, U, yields $U=\sqrt{[2(p_t - p_s)/\rho]}$, where: $\rho = p_s/RT$, or simply $U=\sqrt{(2q/\rho)}$. So to measure the airspeed requires measurement of the dynamic pressure, q, the static pressure, p_s, and the temperature, T.

Precision of a measurement, the number of digits which are read from an instrument, should not be confused with the accuracy of a measurement. The accuracy is inherent in the calibration against a known standard. For example, the temperature probe was checked in an ice bath (0.9 ˚C) and boiling water (97.3 ˚C). The use of several instruments measuring the same parameter lends a bit more confidence in a measurement. Both of these may be overshadowed by random fluctuations in the value of the parameter which can evaluated by taking multiple measurements at different times and calculating the mean, $\bar{U}$, and variance, s^2, of the parameter.

Instrumentation. The primary instrumentation chosen for this experiment was a Pitot-static probe and an inclined manometer for the measurement of the dynamic pressure, q. Vernier Software & Technology equipment was used to measure the static pressure (barometric pressure), p_s, and the ambient temperature, T. The static pressure was checked against the airport barometric pressure reading. The street driven in this preliminary experiment was within 5 miles of the Indianapolis International airport. A relatively calm day was chosen so the airspeeds could be checked against the ground speeds and speedometer readings which were the set points for the experiment.

Test Equipment. The test vehicle was a Chrysler PT Cruiser. To measure the dynamic pressure, a Pitot-static tube marketed by Eagle Tree Systems and a Mark II 0-3" inclined manometer marketed by Dwyer Instruments Inc. (Figure 1).

The remainder of the instrumentation used in this experiment was on-hand having been acquired previously to demonstrate physics phenomena in Physics classes. A Vernier Software & Technology Gas Pressure Sensor to measure the free-stream static pressure (barometric pressure) and a stainless steel temperature probe to measure the free-stream static temperature were used. The temperature measurement was compared to the built-in thermocouples of a number of multimeters. The measured barometric pressure was compared to the reading given by the Indianapolis International airport which was within a few miles of the test site.

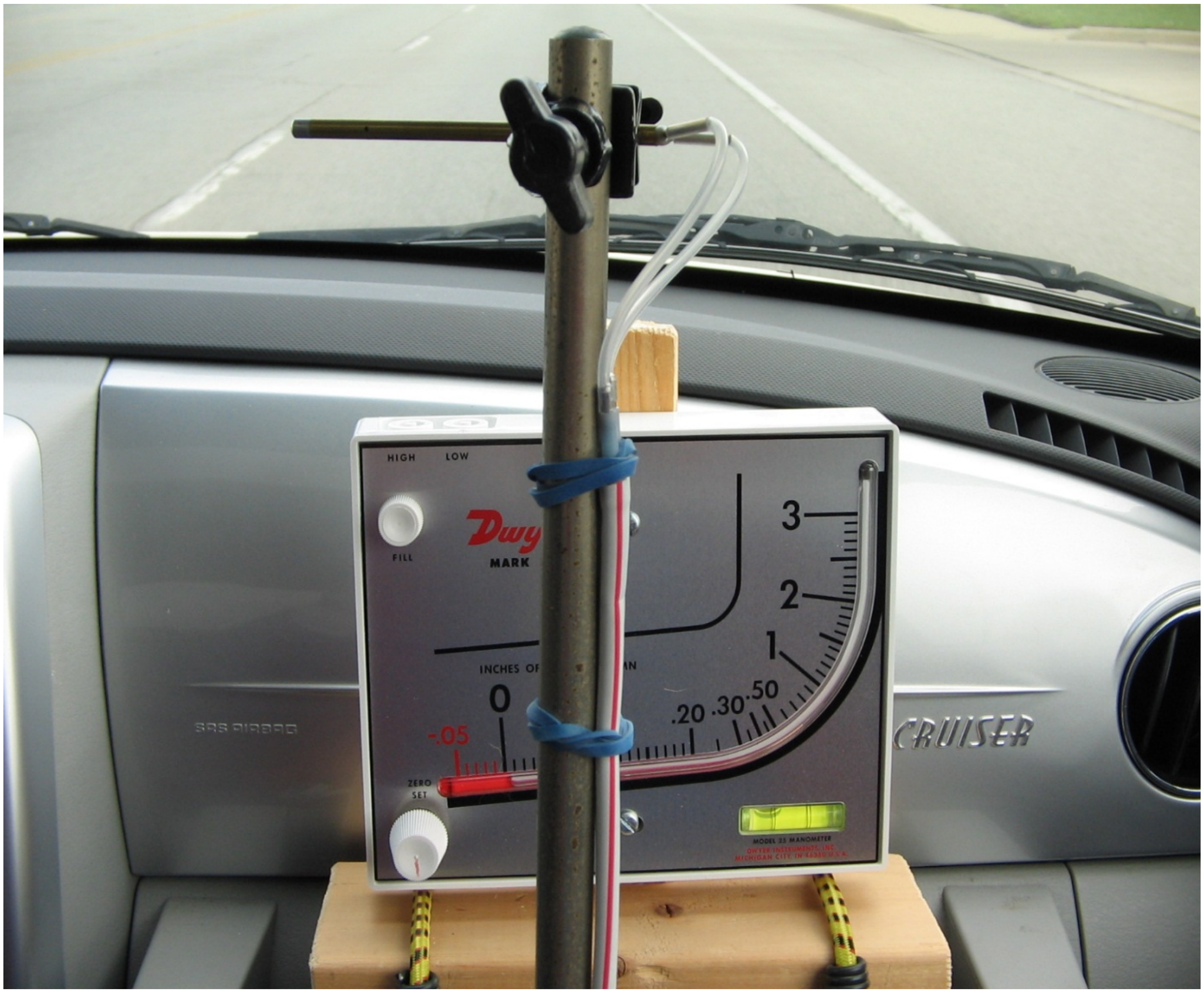

Figure 1. Inclined manometer and Pitot-static probe on the road.

Preliminary Experiment. The wind was relatively calm (10 mph gusting to 15 mph). Dynamic pressure measurements were made at speedometer readings of 20, 30, 40 mph for several passes in a cross-wind direction as well as into the headwind and with the tailwind. The calculated airspeeds were thus based on an average of several readings. Data were recorded on a voice recorder and adjustments were to the inclined manometer and the Pitot-static tube distance from the car and the angle of attack of the tube. Since a car moving at subsonic velocities causes convergence of the streamlines upstream of the car, the probe needs to be sufficiently far outboard to avoid these convergent streamlines. The probe was mounted two feet outboard from the car and was visually aligned for zero angle of attack. The probe should not be overly sensitive to angle of attack since it incorporated four static pressure ports spaced at 90 degree intervals around the periphery of the probe.

Results

Table 1 includes the converted data. The measurements were mixed so they were converted to slug/ft/sec/˚R (slug=lb-sec^2/ft.).

Table 1

19 Nov 2011

Speedometer groundspeed (mph)	U_∞ Airspeed (mph)
20	21.8±4 crosswind ($\bar{U} \pm s$)
30	30±3 crosswind ($\bar{U} \pm s$) (37.6 headwind)
40	37.6 crosswind (47.2 headwind) (31.8 tailwind)

Note. Light South winds (10 mph gusting to 15 mph), T_∞ = 510 ˚R, p_∞ = 2104 psf, $\rho_\infty = p_\infty/RT_\infty$ = 2104/(1716 x 510) = 0.00240 slugs/ft^3, $U_\infty = \sqrt{(2q/\rho)}$ (converted to mph for comparison).

Table 2

19 Nov 2011

Speedometer groundspeed (mph)	U_∞ Airspeed (mph)
45	49.6 headwind 46.5 tailwind
50	51.1±0.6 ($\bar{U} \pm s$) tailwind
60	62.7± a lot

Note. Additional measurements: wind SSW at 13 mph quartering winds.

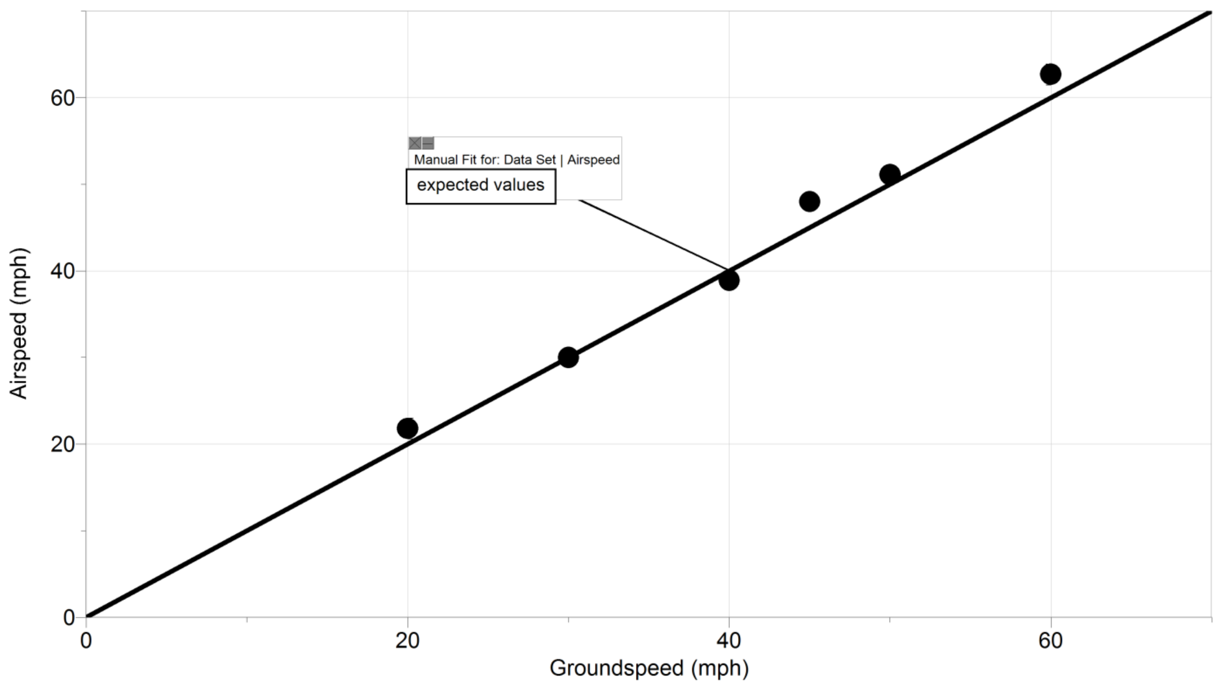

Figure 2. Measured airspeed vs. measured groundspeed.

Since the uncertainty of an automobile speedometer reading is approximately ± 1 mph, the expected airspeed measurement should closely approximate the speedometer reading as illustrated by the straight line in Figure 2. The airspeed measurement depends on the independent measurements of dynamic pressure, static pressure, and temperature, orientation and placement of the Pitot-static probe, and absence of wind gusts. The following analysis yields an estimate of the uncertainty of the airspeed measurement.

Analysis

A requirement by publishers of technical papers and journals is that an uncertainty analysis be made of the measurements which are being reported. As a minimum, the least count/precision of the measuring instrument should be reported. A guide for this analysis may be found in the paper of Kline and McClintock (1953).

We need to estimate the uncertainty in our measurement of the airspeed. $U = \sqrt{(2q/\rho)}$, where: $\rho = p/RT$, or to combine the preceding two equations, $U = \sqrt{(2qRT/p)}$, for the purposes of this analysis. To achieve the uncertainty in our measurement, we have the following definitions and formulas:

w_U: uncertainty in U (1)

w_q: uncertainty in q (2)

w_T: uncertainty in T (3)

w_p: uncertainty in p (4)

$$w_U = \{[(\partial U/\partial q)w_q]^2 + [(\partial U/\partial T)w_T]^2 + [(\partial U/\partial p)w_p]^2\}^{1/2} \quad (5)$$

$$\partial U/\partial q = 1/(2\sqrt{q})(\sqrt{(2RT/p)} = \sqrt{(RT/2pq)} = 4.50 \quad (6)$$

$$\partial U/\partial T = 1/(2\sqrt{T})(\sqrt{(2qR/p)} = \sqrt{(qR/2pT)} = 0.0901 \quad (7)$$

$$\partial U/\partial p = -1/(2\sqrt{p^3})(\sqrt{(2qRT)} = -\sqrt{(qRT/2p^3)} = -0.0221 \quad (8)$$

For nominal values, we use the following:

$q = 2 \pm 0.1$ inches of water $= 10.4 \pm 0.5$ psf z (1)

$T = 520 \pm 2^\circ R$ (2)

$p = 2116 \pm 85$ psf & gas con (3)

$R = 1716$ ft-lbs/slug-$^\circ$R (4)

$$w_U = \{[(4.50)0.5]^2 + [(0.0901)2]^2 + [(-0.0221)85]^2\}^{1/2} = 2.9 \text{ fps}, \text{ i.e. } U = 94 \pm 3 \text{ fps} \quad (5)$$

Conclusions

The preliminary experiment clearly showed that a straight, level road with no camber is desirable due to the high sensitivity of the inclined manometer to curves and tilt of the road. Constant attention must be given to maintaining the manometer level. Attention must also be given to the orientation of the Pitot-static tube to maintain its axis aligned with the free stream direction but that seemed to be less of a problem than maintaining the manometer level. The wakes behind other vehicles cause large fluctuations in the dynamic pressure, so this experiment is best carried out before traffic becomes dense.

The preliminary measurements of airspeed showed good agreement with the measured ground speed (speedometer) when corrected for ambient wind conditions (Figure 2).

Recommendations

As with every experiment, additional avenues for investigation are uncovered. One area for further investigation is the effect on the measurement of the dynamic pressure, q, by varying the angle of attack of the Pitot-static probe. Another area is to evaluate the measured q as a function of the distance of the probe from the vehicle.

Succeeding versions of this project will include more explicit instructions especially concerning plotting the data and diagnosing inconsistencies and their corrections before submitting the final report. Finding the reason for gross differences between the airspeed and ground speed may be the most valuable lesson of the experiment.

General comments

In my previous life with a day job as an experimentalist at the Allison Gas Turbine Engine Research Laboratory, I noticed considerable variation in the barometric pressure as reported by our Test Dept., the Indianapolis airport, and the barometer attached to an isentropic nozzle used to calibrate hot wire anemometers. This has not changed. The uncertainty in the barometric pressure is responsible for one half the uncertainty in the airspeed measurement.

In ASCI 309-Aerodynamics, almost every calculation involves airspeed. The students now have an appreciation for its measurement as well as realizing a real-world application synthesizing the tenets of Math 112-Calculus, Math 211-Statistics, and Phys 102-Physics. This project also has application to ASCI 310, ASCI 509, and ASCI 510.

References

Kline, S.J., & McClintock, F.A. (1953). Describing uncertainties in single-sample experiments. *Mechanical Engineering*, *75*(1), 3-8.

Appendix A

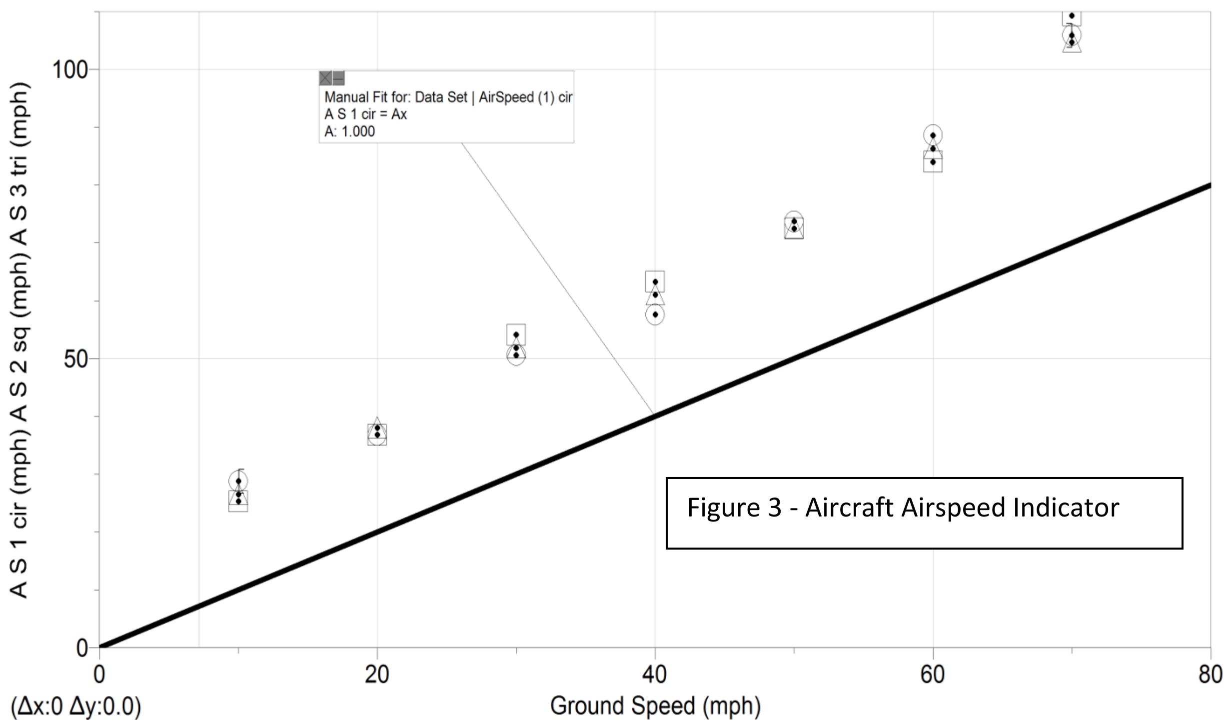

Figure 3. Student Airspeed Measurements 1.

The measurements of seven groups of students are illustrated in Figures 3 and 4. In Figure 3, three groups of students used the same aircraft airspeed indicator and obtained comparable results. The slope appears to be correct however the airspeed indicator appears to have a constant offset of about 20 mph. Probably the instrument zero needs to be adjusted.

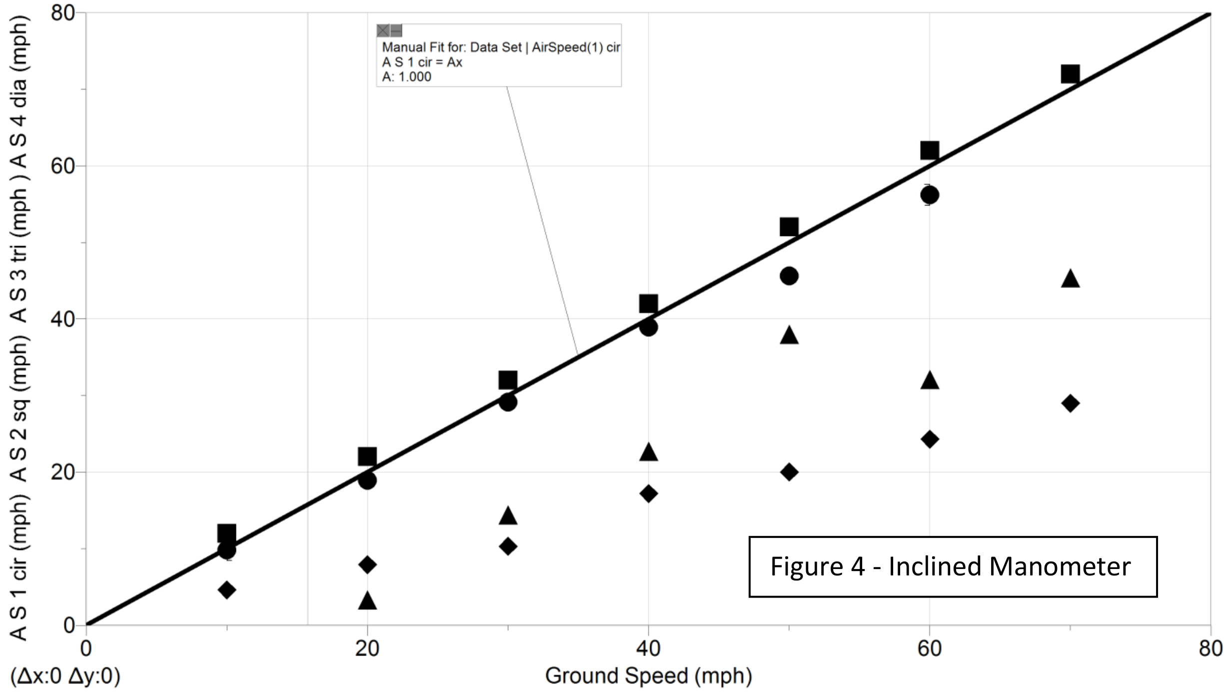

Figure 4. Student Airspeed Measurements 2.

The four groups in Figure 4 used inclined manometers. The two groups designated by filled circles and squares measured an airspeed which agreed with the ground speed. The two groups designated by triangles and diamonds obtained data that could indicate a leak in their total pressure line or the manometer was filled with the wrong fluid, which gave them a measured airspeed about one-half the expected airspeed.

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5. Suggestions for improving the Call for Proposals/Papers and the overall process are:

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