Contents

Table of Contents Continued on the Next Page

Page **Table of Contents Continued**

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Editor

Peter J. Billington, Ph.D.

Professor Emeritus, Colorado State University – Pueblo, CO

editor@beijournal.com

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Using The Time Machine To Gain Historical Perspective In Management Courses

Kellyann Berube Kowalski
University of Massachusetts Dartmouth, North Dartmouth, Massachusetts, USA

ABSTRACT

The time machine is a learning activity that provides students with an active and interesting way to critically think about management history and theory. Students are transported through history to different times, places, and people, providing them with a chance to learn about theories of management within the context they were developed. Understanding the context in which theories were developed provides students with historical perspective that they can use to better understand the present. Time machine activities can be used in courses specifically devoted to management history and theory as well as more mainstream management courses.

Keywords: management history, management education, management theory, active learning, teaching

INTRODUCTION

As an assistant professor I was given a challenge. I was asked to design and teach the management history and theory course that was being added to our curriculum. The theory part sounded okay; I did in fact have a Ph.D. in management so I had studied many organizational theories. Chester Barnard, Max Weber, Abraham Maslow, I could teach that. But management history, now that would be a different story. In fact, I have never liked history. Every history course I have ever taken, in high school or college did not hold my interest. All I remember is names, dates, and events rattled off and lectured at me. Also, as an advisor for management students, anecdotally I knew that history classes were not the elective of choice for most of my advisees. Perhaps they too had previous bad experiences and were now turned off by the subject.

I knew if the class was going to be at all successful, I would have to do two things. First, I would have to get over my own biases about history. Second, I would have to make management history something enjoyable and interesting. But how? I knew nothing about teaching history. So, I went to the library to see if I could get some guidance. I found several textbooks on teaching history, but they were very content specific. Then I found a journal titled, "Journal of Teaching History" and in it found a very interesting and useful article by Susan L. Speaker (1995) entitled "Getting Engaged: Using the Time Machine to Teach History." After reading it I decided to adapt the time machine to my subject area of management history.

MANAGEMENT HISTORY

As noted by Wren (1987), "The study of management history provides examples of theory and practice, illustrates different approaches to management, and identifies great thinkers who have been prominent in refining the practice and theory of management" (p. 339). Just as learning about history in general is an integral part of students' general education, learning about management history is an integral part of management students' business education. Understanding management history can help students to learn the lessons of the past to avoid mistakes in the future (Wren, 1987; Gibson, Hodgetts, & Blackwell, 1999; Thomson, 2001, Smith 2007), and better understand and adapt to change (Wren, 1987; Thomson, 2001; Van Fleet & Wren, 2005, Smith, 2007).

Over the years, many researchers (e.g., Wren, 1987, Gibson et al., 1999; Van Fleet & Wren, 2005; Hartley, 2006; Smith, 2007; Cummings, 2011; Tennent, 2021) have identified the need for the teaching of history in business schools. Despite this research, very few business schools offer courses dedicated specifically to history and most students are only exposed to management history as a very small portion of other mainstream business courses (Gibson et al., 1999; Van Fleet & Wren, 2005). For courses where management history is not the primary focus, textbooks in the field of management have very little coverage of the history of management (Hartley, 2006). With such little coverage, it is difficult for students to understand the context in which management theories were developed.

In addition to limited coverage of history in the management curriculum, there is some belief that it has not been taught as effectively as possible. There has been a call for improved teaching techniques that require students to think more critically (Cummings, 2011). Tennent (2021) suggests a more holistic approach to teaching management history by giving students an "historical context of ideas". In other words, instead of just learning facts about history, students should understand the historical background in which ideas were developed. With so many management theories and ideas, they are often presented hastily without a foundation and understanding of the historical context in which they occurred (Smith, 2007). Students engaged with the history of management are more likely to have positive impacts as future managers, but the quality of teaching materials and the lack of critically looking at history keeps it from being as useful as possible to the future of management (Cummings, 2011).

THE TIME MACHINE

My philosophy and practice of teaching has always been one of active learning. So, in designing and teaching the management history course, I wanted students to do more than just passively memorize history. I wanted them to experience it; to critically think about where the management theories and practices came from and originated and to experience it in the context of history. As future businesspeople, I also wanted them to be able to use that understanding of history to practice management better in the future. Speaker's article about the time machine gave me a jumping off point to develop many different time machine type activities for the course.

Activity prompts

Speaker (1995) provided seven basic templates of the time machine including the simple form, the dialogue, the letter, the memoir, the dinner party or town meeting, the time machine weekend, and Rip van Winkle (see her original article for the actual templates). I have designed time machine activities using many of these templates as well as some of my own design. Some of the prompts that I have used and found to work well in getting students to think critically about history include:

- It is 1832, Charles Babbage and Robert Owen run into each other at an English pub. Over a Bass Ale, the subjects of machines and motivation come up. What are their positions and how to they defend them? Compose their conversation.
- It is 1857 and engineers at the NY and Erie Railroad have gone on strike in protest of the rules, particularly #6, instituted by the Daniel McCallum, the general manager. Version 1: As the engineers on strike, write a letter to the management of the company explaining your position. Version 2: As the management team of the railroad write a letter to the union explaining your position. (Half the students do each version.)
- Frederick Taylor goes to sleep in the United States in 1904 and wakes up in the current year. Curious he observes workers in several different industries, expecting that during the more than 100 years he was asleep his methods have worked to eliminate soldiering. Describe what he would see. Have his methods worked? What has changed? What has not?
- You have traveled back to 1920 Boston to visit Mary Parker Follett. Amazingly she believes you came from the future and is willing to chat with you. She asks you how her ideas on diversity, power, and leadership have been implemented in modern organizations. What do you tell her?
- The year is 1924 and you have recently retired from working on the assembly line at Ford Motor Company, where you worked for sixteen years (from 1908 to 1924). You have been asked by a book publisher to write a brief article about yourself and your experiences at Ford. What do you write?
- You are a manager of a textile factory in the 1930s. Currently you are only using a monetary piece rate system and autocratic leadership to motivate your workers and it doesn't seem to be all that effective. You have recently read about the findings of the Hawthorne Studies and decide that you need to make some changes. Based on the findings of the Hawthorne studies, as specifically as possible, describe the steps you would take in developing a new leadership/motivation system at your factory.
- It is 1935 and you are a business student at Purdue University. Dr. Lillian Gilbreth a mechanical engineering professor at the University and the country's first female engineering professor, is giving an open lecture about the human element in scientific management. You attend the lecture. What does Gilbreth talk about? What are her main points? You get a chance to talk to her after the lecture, what kinds of questions do you ask her?
- You are a sit-down striker at General Motor's Flint Body #1 plant. You have kept a journal for the 44 days the employees have occupied the plant. What would your journal entry say on the first day of the strike (December 30, 1936), on the 23rd day of the strike (January 21, 1937), and on the last day of the strike (February 11, 1937).

- You are currently a CEO of a computer software company that is feeling the effects of a recession. Your company has not shown a profit for the last six quarters. The chairman of the board of your company has sent you a memo indicating his concern. In the memo he tells you about his grandfather who faced a similar situation during the great depression of the 1930s and kept his company afloat by implementing a work sharing program and cutting his own salary. He is suggesting you try this in your company. In a memo to the chairman of the board explain why or why not you think his suggestions would work for your company.

The prompts listed above go along with topics covered in Daniel Wren's, Evolution of Management Thought, textbook, which is currently in its eighth edition (I used the 6th edition). The first edition was published back in 1972 and is considered a primary work in the field, providing important synthesis and direction (Gibson, 1999).

Usage

Although these prompts were originally designed and used in a course specifically devoted to management history and theory, they can be used in many other management courses. In fact, my department no longer offers the management history and theory course for which I originally designed these prompts, but I have continued to use the time machine framework when covering history and theory in other classes I've taught such as human resource management and organizational behavior. Time machine activities could also be used in such classes as principles of management, strategic management, organization theory, and change management, among others.

I have used the time machine in my classes in several different ways. One way that I have used time machine is as team (4-5 students) in-class activities, where students work together to respond to the prompts. Teams will then share their responses with the class in various ways, including reporting out from their seats to the whole class, presenting in front of the class, and sharing with another team. For some time machine prompts, such as the railroad situation above, a debate between two teams works very well. Additionally, I have had students complete the time machine prompts individually as homework assignments and then during class time used their responses to spur discussion as a whole class, in small teams, or in pairs. This method leads to interesting discussion as students can see how their experience of the time machine situation was similar and different than others in the class. Lastly, I have used time machine prompts as essay exam questions as they give students an opportunity to show how they can think critically about a situation and apply theories and ideas from the course.

Student reaction to the using the time machine activities have been positive. Although I still have some students who noted they don't see the value of learning about things that happened in the past, students have had positive things to say about the time machine. Some examples of student comments include:

- "The time machine group activities made the material more interesting and got me to think about the way things were done during different times in history."
- "Time machine questions helped us to get into the minds of those in the past."
- "Discussions based on time machine questions were very engaging and made the history lessons more enjoyable."
- "I feel like the time machine activities let me see history from the viewpoint of those in the past and then connect that to the present and the future."
- "The class activities allowed me to learn a lot about specific individuals and specific situations in depth instead of just getting an overview of management history."

Historical perspective

According to Lawrence (1984), "Historical perspective is the study of a subject in light of its earliest phases and subsequent evolution." It is different from history as its purpose is to better understand the present, not the past (Lawrence, 1984). Time machine activities allow students to experience situations and theories in the context of the person, place, and time that they happened or were developed. Understanding the context in which theories were developed provides students with historical perspective that they can use to better understand the present. This is an important skill to have. Wren (1987) states, "So we may see a manager wrestling with the problem of motivating a modern worker and know that is not the same event as one of 200 years ago, but that the problem of motivation still exists and has always existed" (p. 342) He continues on to say, "Managing today is different from that of last year, the last decade, or whatever date we choose. But how different? How do we know the difference if we have no prior knowledge?" (Wren, 1987, p. 342). Although things change throughout history, being able to truly understand those

changes requires an understanding of the context in which they began. Time machine activities provide students with context that allows them to see and understand the present with historical perspective.

CONCLUSION

The time machine is an activity that gives context to students as they learn about the history and theory of management. It provides them with historical perspective to better understand the present. Students have enjoyed the time machine activities and found them useful. They are not the only ones who have benefitted from the time machine. As someone who never liked history before I taught the management history and theory course, I am now a history enthusiast. I actively seek out opportunities to learn more about all types of history through reading historical fiction, biographies, watching movies and tv series, and visiting museums and other historic sites. I hope in addition to helping them become better managers, the time machine has also spurred students' interest in history.

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Word Puzzles in an Operations Analytics Class

Jaideep T. Naidu, Thomas Jefferson University, Philadelphia, PA, USA

ABSTRACT

Teaching Operations Analytics in business schools requires a review of basic algebra. We spend the first week of the semester to review algebra (or Linear Algebra fundamentals for the School of Engineering). Our classroom experience has been very positive when we reviewed such basics using simple word puzzles. One such word puzzle is a problem related to *Nickels, Dimes, and Quarters* – available on the internet in a variety of forms. It is a simple puzzle, but we make it interesting by going beyond the algebra. We explore the Data Analytics concepts by showing how each additional piece of information (or data) adds value and improves our analysis of the problem. Furthermore, we encourage the student to make logical deductions of possible solutions when we have only partial information available. The students perceive this as fun activity and enjoy the solution process. The student involvement and motivation continue to be high when we discuss topics such as Linear Programming.

Keywords: Word puzzles, Analytics, Algebra, Linear Algebra, Logical Deduction.

INTRODUCTION

Courses such as Operations Management or Management Science have traditionally been more challenging for Business School students. More recently, several colleges have started incorporating the Analytics component into their quantitative courses. We at Thomas Jefferson University are revamping and revising the content in our Business Statistics, MIS, and Operations Management classes. Our traditional Operations Management course is now called *Operations and Data Analytics*. Our course revisions include experimenting with software such as R and Tableau while retaining Excel as the primary and predominant software tool in the classroom.

Because of the availability of high-quality data, executives are no longer content with decisions based only on intuition and instinct; they require data (Liberatore & Luo, 2010). Analytical executives like Harrah's CEO Gary Loveman, have coined the mantra, "Do we think this is true? Or do we know?" (Davenport, 2006). Recent studies stressed on the importance of data in their definition of business analytics. One definition is: "*Business analytics* is an evolving phenomenon that reflects the increasing significance of data in terms of its growing volume, variety and velocity" (Mortenson, Doherty & Robinson, 2015). Another definition is: By *analytics* we mean the extensive use of data, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions" (Davenport & Harris, 2007). These definitions help us in the classroom as an introduction to Analytics before demonstrating the value of data or information.

Despite current trends related to business analytics and related software tools, Operations Management as a course still requires a reasonably good background in algebra. The business majors do better with a refresher in basic algebra. The Engineering majors benefit by a refresher in Linear Algebra fundamentals – especially if the Professor is teaching the Simplex Algorithm later in this course. We have always devoted the first week of the semester to review basic algebra in our Operations classes. While the students do appreciate the Professor's attempt to review basic Math, they do not seem motivated when we simply review a bunch of Algebra (or Linear Algebra) problems. Our experience has shown that word puzzles have always made the class very interesting and significantly improved class participation. Furthermore, the students maintain a high level of involvement when we eventually discuss topics like Linear Programming and Integer Programming. While we do not teach the Simplex Algorithm to business majors, we do stress on enhancing their ability to convert various word problems into LP or IP models. Our experience has been that students struggle more with Linear Programming and Integer Programming because of the Math and the challenge in interpreting word problems and converting them into algebra. Even students who are good with quantitative material are not too comfortable with word problems. Hence, word puzzles provide an interesting start to the semester and the student gains confidence when we tackle more difficult problems later in the semester.

The purpose of this paper is multifold. We introduce elementary word puzzles in the classroom for multiple reasons. We demonstrate how to convert the information into algebraic equations and then solve those equations. We then address the scenario with only partial information of such puzzles and encourage the students to think logically and arrive at the final solution or a set of possible solutions. Furthermore, we discuss the fundamental ideas of Data Analytics and explain how every piece of information of the puzzle adds value to our analysis and improves the solution process. Lastly, we present the Gaussian Elimination and Gauss-Jordan Elimination methods of Linear Algebra in an Appendix to solve one variant of a word puzzle.

THE NICKELS, DIMES, AND QUARTERS PUZZLES

Formulating word problems into algebra requires can be a challenge for undergraduate students. Word puzzles have helped us in instilling confidence in them. There are several word puzzles that can be solved in very little time. One such puzzle is related to *Nickels, Dimes and Quarters* and there are several variants of it available on the internet: https://www.algebra.com/algebra/homework/word/coins. In this paper, we present three simple variants of this puzzle. We discuss Variant 1 in detail but omit the matrix solutions for the other two variants. Discussing such puzzles keep the students engaged and also help in refreshing their algebra skills. In the case of the Engineering students, we provide a review of Linear Algebra. Both groups of students benefit when word problems are formulated into algebra. The students also appreciate the value of quality data when the focus is on Analytics. Furthermore, we challenge the students by encouraging them to use logical deduction approaches if only partial information is available.

VARIANT 1: The Nickels, Dimes, and Quarters puzzle

In your pocket, you have nickels, dimes, and quarters. There are 12 coins altogether and exactly twice as many dimes as nickels. The total value of the coins is $2.00. Find the number of coins of each type.

Algebraic formulation: Let N, D, and Q represent the number of nickels, dimes, and quarters respectively. It is important to assume that $N \geq 1$, $D \geq 1$, and $Q \geq 1$ and it is implied that they are all integers. The second sentence has two pieces of information and results in equations 1 and 2. Finally, the third sentence of the Problem statement results in the third equation. The equations are:

$N + D + Q = 12$ ➔ Equation 1

$2N - D = 0$ ➔ Equation 2

$N + 2D + 5Q = 40$ ➔ Equation 3 (*Note*: This is the simplified form of the original equation: $5N+10D+25Q = 200$).

Solution: From Equation 2, we have $D = 2N$. Substituting this in equations 1 and 3, we obtain

$3N + Q = 12$ ➔ Equation 4

$N + Q = 8$ ➔ Equation 5

Solving equations 4 and 5, we obtain $N = 2$; $Q = 6$. From equation 1, we obtain $D = 4$. *Hence, there are 2 Nickels, 4 Dimes and 6 Quarters in your pocket*.

A Logical Deduction exercise of Variant 1 with partial information

Suppose Variant 1 of the puzzle is now modified as: *In your pocket, you have nickels, dimes, and quarters. There are 12 coins altogether. The total value of the coins is $2.00. Find the number of coins of each type*.

Note that we no longer have the earlier information of twice as many dimes as nickels. This means, we only have Equations 1 and 3 to work with. From equation 1, we obtain $N = 12 - D - Q$. Substituting this into equation 3 and simplifying, we obtain $D + 4Q = 28$. Now, it is a case of logical deduction. We consider all feasible values of Q (i.e., Q = 1, 2, 3, 4, 5, and 6). This results in only one feasible solution (see Table 1 below). This analysis demonstrates that logical deduction approaches are valuable, and we may be able to find solutions without having complete information.

TABLE 1

Q	D	N	Feasible/Not Feasible
1	24	-13	Not Feasible
2	20	-10	Not Feasible
3	16	-7	Not Feasible
4	12	-4	Not Feasible
5	8	-1	Not Feasible
6	**4**	**2**	**Feasible**

Note: We obtain D by using the equation $D + 4Q = 28$. We obtain N by using the equation $N + D + Q = 12$. And for all $N \leq 0$, the solutions are not feasible.

A discussion of Data Analytics with Variant 1

Data Analytics has several definitions as given by researchers in an earlier section of this paper. And *data* is the very core of analytics. There can be no analytics without data or information. While real-world examples are important, the Nickels, Dimes, and Quarters puzzle illustrates the value of data in an Introductory Analytics class. The students appreciate how additional data improves the analysis of a problem and results in more accurate conclusions.

Consider the first sentence of Variant 1: *In your pocket, you have nickels, dimes, and quarters.* If the question is to figure out the number of coins of each type from this sentence, it is not possible as there can be an *infinite or a large number of solutions*. The first sentence is still an example of "data" since it provides the basic information that you have nickels, dimes, and quarters in your pocket and that $N \geq 1$, $D \geq 1$, $Q \geq 1$ and integers. Now consider the first part of the second sentence: *there are 12 coins altogether*. This is an example of quality data since the number of possible solutions is now reduced drastically to *55 solutions* as shown below in **Table 2** – a set of 10 sub-tables.

TABLE 2

N	D	Q
1	1	10
1	2	9
1	3	8
1	4	7
1	5	6
1	6	5
1	7	4
1	8	3
1	9	2
1	10	1

N	D	Q
2	1	9
2	2	8
2	3	7
2	4	6
2	5	5
2	6	4
2	7	3
2	8	2
2	9	1

. . . .

N	D	Q
9	1	2
9	2	1

N	D	Q
10	1	1

Thus, the number of solutions = 10 + 9 + 8 + 7 + 6 + 5 + 4 + 3 + 2 + 1 = 55 i.e., the sum of the first 10 positive integers. The second piece of the second sentence of the puzzle i.e., *there are twice as many dimes as nickels* is also an example of quality data. Incorporating both parts of this sentence results in only *three solutions* as given in Table 3 below.

TABLE 3

N	D	Q
1	2	9
2	**4**	**6**
3	6	3

Finally, the third sentence of the Problem Statement i.e., *The total value of the coins is $2.00* results in only *one possible solution* i.e., N = 2; D = 4; Q = 6. The other two solutions do not add up to $2.00. This example illustrates the fundamental idea of data analytics since our understanding of the problem increased with each additional piece of information or data. In the real world too, quality data results in better understanding of the problem, better predictions and the ability to provide unique solutions. However, we inform the student that real-world problems may not have simple solutions and that our puzzle was to only illustrate the concept of improved information with additional data.

VARIANTS 2 AND 3 OF THE NICKLES, DIMES AND QUARTERS PUZZLE

In this section, we present Variant 2 and Variant 3 of the Nickels, Dimes, and Quarters puzzle as Student Exercises. We provide the algebraic solutions, the logical deduction methods, and the data analytics related discussion. The instructor may choose to also discuss Variant 2 in the classroom and assign Variant 3 as homework.

VARIANT 2: The Nickels, Dimes, and Quarters puzzle

In your pocket, you have nickels, dimes, and quarters. There are 14 coins altogether and one more nickel than dime. The total value of the coins is $1.55. Find the number of coins of each type.

Algebraic formulation: Based on Variant 2, the equations are:

N + D + Q = 14 ➔ Equation 1

N – D = 1 ➔ Equation 2

N + 2D + 5Q = 31 ➔ Equation 3 (*Note*: It is the simplified form of the original equation 5N + 10D + 25Q = 155).

Solution: From Equation 2, we have N = D + 1. Substituting this in equations 1 and 3, we obtain

2D + Q = 13 ➔ Equation 4

3D + 5Q = 30 ➔ Equation 5

Solving equations 4 and 5 results in D = 5; Q = 3. From equation 1, we obtain N = 6. *Hence, there are 6 Nickels, 5 Dimes and 3 Quarters in your pocket*.

A Logical Deduction exercise of Variant 2 with partial information

Suppose Variant 2 of the puzzle is now modified as: *In your pocket, you have nickels, dimes, and quarters. There are 14 coins altogether. The total value of the coins is $1.55. Find the number of coins of each type*.

Note that we no longer have the earlier information of one more nickel than dime. This means, we have only Equations 1 and 3 to work with. From equation 1, we obtain N = 14 – D – Q. Substituting this into equation 3 and simplifying, we obtain D + 4Q = 17. Now, it is a case of logical deduction. We consider all possible values of Q (i.e., Q = 1, 2, 3, and 4). This results in a total of three feasible solutions (see Table 4 below). Interestingly, all three solutions are possible since they add up to $1.55. Thus, this is an example where the lack of the additional data/information of "one more nickel than dime" prevents us from arriving at a single unique solution.

TABLE 4

Q	D	N	Feasible/Not Feasible
1	13	0	Not Feasible
2	**9**	**3**	Feasible
3	**5**	**6**	Feasible
4	**1**	**9**	Feasible

Note: We obtain D by using the equation D + 4Q = 17. We obtain N using the equation N + D + Q = 14. And for all N ≤ 0, the solutions are not feasible.

Data Analytics with Variant 2

As in the case of Variant 1, the first sentence of Variant 2 also results in an infinite number of solutions. Now, consider the first part of the second sentence: *there are 14 coins altogether*. This is an example of quality data since the number of possible solutions is reduced drastically to only *78 solutions*. The rationale is same as the set of sub-tables in Table 2 except that in this case, the set of Tables would start with 12 combinations. Hence, the sum of the first 12 positive integers = 78. The second part of the second sentence i.e., *one more nickel than dime* is another example of quality data. Incorporating both pieces of the second sentence results in only *six possible solutions* as given in Table 5 below.

TABLE 5

N	D	Q
2	1	11
3	2	9
4	3	7
5	4	5
6	**5**	**3**
7	6	1

Finally, the third sentence of the Problem Statement i.e., *the total value of the coins is $1.55* results in only *one possible solution* i.e., N = 6; D = 5; Q = 3. The other five solutions do not add up to $1.55.

VARIANT 3: The Nickels, Dimes, and Quarters puzzle

In your pocket, you have nickels, dimes, and quarters. There are 20 coins altogether and exactly twice as many dimes as nickels. The total value of the coins is $3.00. Find the number of coins of each type.

Algebraic formulation: Based on Variant 3, the equations are:

N + D + Q = 20 ➔ Equation 1

2N – D = 0 ➔ Equation 2

N + 2D + 5Q = 60 ➔Equation 3 (*Note*: This is the simplified version of the original equation 5N+10D+25Q = 300).

Solution: From Equation 2, we have D = 2N. Substituting this in equations 1 and 3, we obtain

3N + Q = 20 ➔ Equation 4

N + Q = 12 ➔ Equation 5

Solving equations 4 and 5 results in N = 4; Q = 8. From equation 1, we obtain D = 8. *Hence, there are 4 Nickels, 8 Dimes and 8 Quarters in your pocket*.

A Logical Deduction exercise of Variant 3 with partial information

Suppose Variant 3 of the puzzle is now modified as: *In your pocket, you have nickels, dimes, and quarters. There are 20 coins altogether. The total value of the coins is $3.00. Find the number of coins of each type*.

Note that we do not have the earlier information of twice as many dimes as nickels and have only Equations 1 and 3 to work with. From equation 1, we obtain N = 20 – D – Q. Substituting this into equation 3 and simplifying, we obtain D + 4Q = 40. Now, it is a case of logical deduction. We consider all possible values of Q (i.e., Q = 1, 2, 3, 4, 5, 6, 7, 8, and 9). This results in a total of three feasible solutions (see Table 6 below). Interestingly, all three solutions are possible since they add up to $3.00. Thus, this is also an example where the lack of the additional data/information of "twice as many dimes as nickels" prevents us from arriving at a single unique solution.

TABLE 6

Q	D	N	Feasible/Not Feasible
1	36	-17	Not Feasible
2	32	-14	Not Feasible
3	28	-11	Not Feasible
4	24	-8	Not Feasible
5	20	-5	Not Feasible
6	16	-2	Not Feasible
7	**12**	**1**	**Feasible**
8	**8**	**4**	**Feasible**
9	**4**	**7**	**Feasible**

Note: We obtain D by using the equation D + 4Q = 40. We obtain N by using the equation N + D + Q = 20. And the solutions are not feasible for all N ≤ 0.

Data Analytics with Variant 3

As in the case of Variant 1, the first sentence of Variant 3 also results in an infinite number of solutions. Now, consider the first part of the second sentence: *there are 20 coins altogether*. This is an example of quality data since the number of possible solutions is now reduced drastically from an infinite number of solutions to only *171 solutions*. The rationale is same as the set of sub-tables in Table 2 except that in this case, the set of Tables would start with 18 combinations. Hence, the sum of the first 18 positive integers = 171. The second part of the second sentence of the Problem statement i.e., *there are twice as many dimes as nickels* is another example of quality data. Incorporating both pieces of the second sentence results in only *six possible solutions* as given in Table 7 below.

TABLE 7

N	D	Q
1	2	17
2	4	14
3	6	11
4	**8**	**8**
5	10	5
6	12	2

Finally, the third sentence of the Problem Statement i.e., *the total value of the coins is $3.00* results in only *one possible solution* i.e., N = 4; D = 8; Q = 8. The other five solutions do not add up to $3.00.

CONCLUDING REMARKS

Our experience has been that the typical business school student starts an Operations Analytics class with a certain amount of anxiety and concern. We spend the first week of this class by reviewing basics of algebra to instill confidence in our students. While our past attempts of solving some high school algebra problems were certainly appreciated, we realized that the class participation is higher when we use simple word puzzles instead. The students enjoy solving such puzzles and the objective of an algebra refresher is also achieved. The students gain confidence and stay motivated, and it helps when we tackle word problems in topics such as Linear Programming and Integer Programming. The students also enjoy the logical deduction exercises in arriving at solutions when only partial information is available. Furthermore, we also introduce the Analytics component during this first week itself using these word puzzles. Our students appreciate the value of quality data and how it improves our analysis and understanding of the problem which then results in more informed decisions and better predictions.

Finally, we present the Gaussian Elimination and Gauss-Jordan Elimination methods of Variant 1 of the Nickels, Dimes and Quarters puzzle in an Appendix. This exercise benefits the Engineering students if the Simplex Algorithm of Linear Programming is discussed in the classroom.

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Jaideep T. Naidu, Ph.D., is an Associate Professor of Operations and Data Analytics at Thomas Jefferson University. He has published in peer reviewed journals that include *Omega*, *Journal of the Operational Research Society*, *Business Education Innovation Journal*, and *AIMS International Journal of Management*.

APPENDIX

We solve Variant 1 using the Gaussian Elimination and Gauss-Jordan Elimination methods. We solve the linear system of equations simultaneously (Larson, 2017) so that the student can see the algebra during this process.

Linear System	**Associated Augmented Matrix**
$N + D + Q = 12$ $N + 2D + 5Q = 40$ $2N - D = 0$	$\begin{bmatrix} 1 & 1 & 1 & 12 \\ 1 & 2 & 5 & 40 \\ 2 & -1 & 0 & 0 \end{bmatrix}$
Add the 1st equation to the 3rd equation. $N + D + Q = 12$ $N + 2D + 5Q = 40$ $3N + Q = 12$	Add row 1 to row 3 to produce a new row 3. $\begin{bmatrix} 1 & 1 & 1 & 12 \\ 1 & 2 & 5 & 40 \\ 3 & 0 & 1 & 12 \end{bmatrix}$ R3 + R1 ➔ R3
Add –1 times the 1st equation to the 2nd equation. $N + D + Q = 12$ $D + 4Q = 28$ $3N + Q = 12$	Add –1 times row 1 to row 2 to produce a new row 2. $\begin{bmatrix} 1 & 1 & 1 & 12 \\ 0 & 1 & 4 & 28 \\ 3 & 0 & 1 & 12 \end{bmatrix}$ R2 + (–1) R1 ➔ R2
Add –1 times the 2nd equation to the 1st equation. $N - 3Q = -16$ $D + 4Q = 28$ $3N + Q = 12$	Add –1 times row 2 to row 1 to produce a new row 1. $\begin{bmatrix} 1 & 0 & -3 & -16 \\ 0 & 1 & 4 & 28 \\ 3 & 0 & 1 & 12 \end{bmatrix}$ R1 + (–1) R2 ➔ R1
Add –3 times the 1st equation to the 3rd equation. $N - 3Q = -16$ $D + 4Q = 28$ $10Q = 60$	Add –3 times row 1 to row 3 to produce a new row 3. $\begin{bmatrix} 1 & 0 & -3 & -16 \\ 0 & 1 & 4 & 28 \\ 0 & 0 & 10 & 60 \end{bmatrix}$ R3 + (–3) R1 ➔ R3
Multiply the 3rd equation by 1/10. $N - 3Q = -16$ $D + 4Q = 28$ $Q = 6$	Multiply row 3 by 1/10 to produce a new row 3. $\begin{bmatrix} 1 & 0 & -3 & -16 \\ \mathbf{0} & 1 & 4 & 28 \\ \mathbf{0} & \mathbf{0} & 1 & 6 \end{bmatrix}$ (1/10)R3 ➔ R3

Note: The matrix is now in row-echelon form. Using back-substitution, substituting Q = 6 from the 3rd equation into equations 1 and 2 results in N = 2 and D = 4. We continue to reduce the matrix into a reduced row-echelon form.

Add –4 times the 3rd equation to the 2nd equation $N - 3Q = -16$ $D = 4$ $Q = 6$	Add –4 times row 3 to row 2 to produce a new row 2. $\begin{bmatrix} 1 & 0 & -3 & -16 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 6 \end{bmatrix}$ R2 + (–4) R3 ➔ R2
Add 3 times the 3rd equation to the 1st equation $N = 2$ $D = 4$ $Q = 6$	Add 3 times row 3 to row 1 to produce a new row 1. $\begin{bmatrix} \mathbf{1} & 0 & 0 & 2 \\ 0 & \mathbf{1} & 0 & 4 \\ 0 & 0 & \mathbf{1} & 6 \end{bmatrix}$ R1 + 3R3 ➔ R1

Graduate Business Student Performance in a Hybrid Class

Lynn A. Fish, Canisius College, Buffalo, NY USA

ABSTRACT

Prior research on student performance with different content delivery formats shows mixed results and often occur across semesters, students, and instructors. This study compares graduate business student performance in an operations management course for content delivered in a hybrid course where content delivery is both face-to-face and online to the same students by the same instructor in the same semester. Results demonstrate a significant difference in student performance and favor face-to-face content delivery.

Keywords: Hybrid, Graduate business students, Performance

INTRODUCTION

Administrators argue that online learning is the same or superior to those in the traditional face-to-face (FTF) classroom (Allen & Seaman, 2013); however, critics argue that due to intrinsic differences online education does not replicate the learning that occurs in the FTF classroom (Bejerano, 2008). Correctly or incorrectly, instructors assume that whenever they implement information technology in a classroom, it contributes to student learning (Peng, 2009). However, instructors should evaluate the various assessment activities used to evaluate student performance and enhance the learning environment to verify the relevance to students learning (e.g. Braunscheidel, Fish & Shambu, 2013; Fish, 2015, 2017; Santos, Hu & Jordan, 2014; Weldy, 2018). In general, when instructors enthusiastically embrace online education and carefully integrate assignments and course materials, the students embrace it as well (Arasasingham et al., 2011). Researchers have explored student performance in courses which are offered online, FTF and web-enhanced (which includes hybrid). With this in mind, the question before us is: Do graduate students perform the same for content delivered in the online environment as in the FTF environment?

Review of the Literature. Specific definitions for online, hybrid and FTF vary as technology continues to change and classes change to include different, up-to-date technological elements. FTF content delivery refers to the traditional instructor lecture style where the students and instructors are in the same physical location at the same time. In FTF instruction, the instructor lectures and interacts with the students, answering questions and encouraging participation in real-time. Online delivery refers to all instructional materials being located online and delivered asynchronously, such as instructor pre-recorded lectures that are passive and do not allow for real-time questioning. In 'pure online' course delivery, the instructor does not meet synchronously to answer a student's questions in real-time. Hybrid or web-enhanced courses occur in a variety of forms. In this study, hybrid refers to content delivery through an 'every other week' format whereby the students participate one week in FTF content delivery and the next week in 100% online delivery.

Many studies researched student performance in various educational formats: FTF, online and hybrid. Several studies found that traditional FTF education yields better student performance than web-based performance (Coates, Humphreys, Kane & Vachris, 2004; Crawford, 2008; Evans, 2015; Flanigan, 2014; Grotton-Lavoie& Stanley, 2009; Mahmood, MahMood & Malik, 2012; Metzgar, 2014; Trawick, Lile & Howsen, 2010; Verhoeven & Rudchenko, 2013). Contrastingly, other studies found that student performance in web-based classes is better than traditional FTF (Gratton-Lavoie & Stanley, 2009; Harmon, Alpert, & Lambrinos, 2014; Means, Toyama, Murphy, Bakia, & Jones, 2010). Additionally, other studies showed no difference in student performance between traditional FTF and web-based instruction (Cavanaugh, & Jacquemin, 2015; Larson & Sung, 2009; Ni, 2013; Olitsky & Cosgrove, 2014; Stack, 2015; Terry, 2007; Zacharis, 2010). In yet another study, researchers found that student performance was higher for instruction that combined FTF lecture and online components than purely FTF instruction or purely online instruction (Angiello, 2010). In a 2010 meta-analysis study, the U.S. Department of Education indicated that hybrid teaching is the most effective instruction approach to achieve better student learning outcomes than courses that are entirely online or entirely FTF (Means, Toyama, Murphy, Bakia, & Jones, 2010; Molnar, 2017). In a study of graduate business student performance over a decade ago, student performance on class assignments delivered through FTF, online, and hybrid formats were the same (Terry, 2007). Additionally, while not statistically significant, the study found that graduate online students performed over 4% lower on the final exam than graduate students who learned material in FTF or hybrid delivery (Terry, 2007). These studies have occurred in various business and non-business courses, for graduate and undergraduate students, with large and small sample sizes and at various sized Universities. Results are

obviously mixed; however, most studies evaluate student performance across different instructors or semesters or students. A hybrid course, taught by the *same instructor* to the *same students* in the *same semester*, offered a unique opportunity to analyze student performance on content delivered FTF versus online.

Statement of the Problem. This study evaluates the impact of different educational formats in a hybrid class - specifically online and FTF content instruction on graduate business student performance where the content is delivered by the same instructor for the same course in the same semester to the same cohort. The specific research question is: *Did graduate students perform the same on content delivered in FTF and online?* Specifically, this study seeks to explore the following hypothesis:

Student Performance on FTF versus Online Content:

Ho1: There is no difference between student performance for content delivered in the FTF and online environment.

H11: There is a difference between student performance for content delivered in the FTF and online environment.

METHOD

With increasing graduate business student demands to offer more online components in programs, an AACSB-accredited University in the northeast began the transition to a hybrid program in 2019. In the spring of 2020, prior to the pandemic, an instructor taught an operations management course as a hybrid course. By hybrid, the format for delivery entailed an 'every-other' week FTF session – online session transition. The course began with the students attending class the first night to review material in a FTF environment. Then the following week, the students completed the material online. In the third week, the students returned to the FTF environment to take a quiz on the prior 2 weeks of material and cover content in the FTF environment. This pattern of content delivery whereby material was reviewed FTF, then online, then a quiz on the two weeks of material in a FTF setting repeated itself over the semester. The University prides itself on being a teaching University with small class sizes (average 17) and significant instructor-to-student interaction. Students typically regard the operations management course as 'difficult' as it includes qualitative and quantitative content that they do not have prior experience on. Topics covered (outlined here in the sequence they were covered) include introduction to operations management, process analysis, quality management and statistical process control, supply chain design and integration, layout design, forecasting, sustainability, capacity management, inventory management, operations planning, resource planning, Material Requirements Planning, scheduling, and lean systems. The same instructor taught two sections of the hybrid course (where one week the class was FTF and the next week they were online) in the same semester. Prior to the pandemic shut down, topics covered included introduction to operations through sustainability. Given the nature of the material, the instructor purposely chose the most qualitative topics with the simplest quantitative tools for online education – process analysis, supply chain design and integration, and sustainability. Over the first eight weeks of the course, the only quantitative techniques that the instructor reviewed online included break-even analysis and preference matrices. Both of these techniques are very simple and not complicated to learn. However, in the FTF class, the instructor reviewed the more challenging and intricate techniques associated with statistical process control charting, assembly line balancing and process layout. Whether it was an online or FTF week, student expectations included reading the corresponding textbook material. The instructor conducted FTF classes in a traditional lecture format with student participation. For both online and FTF sessions, instructor handouts with an outline of the class were given to the students as the basis for their notetaking. It is important to understand that the University does not utilize instructional designers and the instructor is responsible for the design and content in the course for any online and FTF materials. For online weeks, the instructor posted videotapes online of the traditional lecture to the course learning management system (LMS). During online sessions, students listened to the videotapes and completed the course handouts – similar to their FTF class sessions, but without the immediate ability to ask questions and receive answers. Students could contact the instructor with questions on the online content at any time. Additionally, the instructor provided suggested problems with solutions to the LMS for each topic.

The graded requirements for the course included quizzes, homework assignments, individual assignments, a midterm and a final exam. The instructor administered 5 quizzes over the semester, with the 4 best scores counting toward a student's overall grade, and quizzes accounted for 25% of a student's overall grade. The student completed 10 online homework assignments that were administered through a notable textbook publisher with a focus on mastery through 3 attempts on each problem, and the homework grade counted toward 10% of a student's overall grade. Students were required to complete 3 individual written assignments, worth 15% of the student's overall grade. A non-cumulative

midterm and final exam were each worth 25% of a student's overall grade. Prior to the pandemic, the instructor administered three quizzes in class. Quizzes included multiple choice questions, short answer questions and quantitative problems. The testing was 'closed book and notes', students were limited to a basic calculator, and the instructor provided all formulas for testing. Quiz content include two weeks of material (one FTF session reviewed two weeks prior to the quiz and one online session reviewed online a week prior to the quiz). Each quiz took roughly 25 minutes to administer in-class. The midterm was administered in the FTF class, covered the material that was taught FTF and online, and consisted of 30 multiple choice questions, 5 short answer questions and 6 quantitative questions.

An example of a multiple-choice question from the midterm is:

The ease with which equipment and employees can handle a wide variety of products, output levels, duties and functions, is known as:
a. customer involvement
b. resource flexibility
c. capital intensity
d. line process

Similarly, an example of a short answer question is:

Describe a job shop [2 points], and its customer involvement, capital intensity and resource flexibility. [3 points]

An example of a quantitative question from the midterm is:

Joseph's Tailoring makes custom designed shirts for men. The shirts could be flawed in various ways, including flaws for weave or color, loose buttons or holes in the fabric. The manager examined shirts each day over a week; however, the number of shirts made each day could vary. Given the information in the table below:

Day	1	2	3	4	5
# Defects	18	13	17	12	22

a. Determine 3-sigma control limits to help the manager monitor quality. [3 points]
b. If on the 6th day, the manager found 25 defects, is the process in control?
Yes No Undecided Why or why not? [2 points]

For this study, for content delivered through FTF instruction, there were 29 multiple choice questions, 6 short answer questions (18 points total) and 7 quantitative questions (39 points total). For content delivered online, there were 15 multiple choice questions, 4 short answer questions (16 points total) and 2 quantitative questions (8 points total). The instructor graded all quiz and exam short-answer and quantitative problems, and awarded partial credit using a rubric for consistency between students. For purposes of this study, the instructor recorded the FTF and online question results for multiple choice, short answer and quantitative questions for each student. Due to COVID, the course transitioned to 100% online and the last quizzes and final exam were administered online, and therefore could not be used in this study. In keeping with University requirements, student permission to use their performance was noted and obtained through the course syllabus. Homework results were not included as the focus of the homework assignments was on mastery of the technique with multiple tries, 'hints' were given, and the event was recorded online versus in a classroom setting. In completing the homework, students also had access to the other students, the instructor, textbook and notes.

ANALYSIS

In the spring of 2020, COVID19 interrupted many lives – and the University switched to fully online following the eight-weeks of classes. For purposes of this study, only the first eight weeks of the course resulted in a FTF-to-online session comparison whereby the testing was the same for all students (that is, in-class FTF testing proctored by the instructor). All 54 students participated in this study and received both online and FTF instruction in the 'hybrid' class. There were 25 students in one section and 29 in the other section taught by the same instructor. The instructor gathered all question results and coded them as material reviewed FTF or online, and whether the question was a multiple choice, short answer or quantitative question. Since the number of points for FTF and online were not equal, for

comparison purposes, student scores were calculated as a percentage. As shown in Table 1, paired t-test analysis (two-tails) showed a significant difference (p=.000) for student performance on FTF and online content. Students performed significantly better on average for content administered FTF than online. In particular, they performed significantly better on short answer questions (p=.0210) covered FTF than online. The results show a slight significance for multiple choice questions (p=.0776). There was no statistical difference (p=.1666) on quantitative questions between content covered in-class versus online.

Table 1: Comparison of Student Performance on FTF and Online Administered Content.

Question Type	FTF Average	Online Average	T-Test
Multiple Choice	75.48	72.1	.0776 **
Short Answer	69.01	63.80	.0210 *
Quantitative	86.75	83.22	.1666
Total	79.24	70.98	.0000 *

*$p \leq .05$, ** $p \leq .10$

DISCUSSION

Research regarding the effectiveness of different educational formats is mixed. These studies typically compared different students in different treatments. This study analyzed the *same graduate student* in both FTF and online treatments and their performance on content delivered in each method was tested simultaneously. The *same instructor delivered the material* in the *same semester to the same students*. Regardless of the question type, students performed better on average for content delivered in the FTF environment than online. Analysis revealed a significant difference in student performance between FTF and online delivered content and favored the traditional FTF method. These results support the research that favored FTF content delivery over online or web-enhanced content delivery (Coates, Humphreys, Kane & Vachris, 2004; Crawford, 2008; Evans, 2015; Flanigan, 2014; Grotton-Lavoie& Stanley, 2009; Mahmood, MahMood & Malik, 2012; Metzgar, 2014; Trawick, Lile & Howsen, 2010; Verhoeven & Rudchenko, 2013). Specific to graduate students, these results contrast the older study that showed no significant differences between FTF, online and hybrid in graduate business student performance (Terry, 2007). This is particularly interesting as the FTF material was administered two weeks prior to the online material for quiz testing, and typically covered more difficult material that also required quantitative understanding of the topic.

With respect to the different testing formats, graduate students showed a significant difference in their performance on short answer questions and a slight significance on multiple choice, but not on quantitative questions. As for the lack of a significant difference in the quantitative performance, perhaps this result can be attributed to the fact that the easier quantitative techniques were reviewed online, and the analysis only included a few questions on online quantitative content. Also, the online homework encouraged mastery of the methods through the three attempts. If the complexity of the quantitative problems taught online had been more, perhaps the results on quantitative questions may have been different.

Clearly, the results support significant difference in graduate student performance between FTF and online instructor administered content, and favor the traditional FTF administered format. As most graduate students have been taught through traditional FTF educational systems, it may also indicate that graduate students at this teaching institution may not be as acclimated to online education at this time. Perhaps, following the pandemic and graduate students' participation in 100% online education, results may be different.

Limitations. Due to the pandemic, student performance included results for only 3 quiz results and 1 midterm. Completion of the entire semester would have allowed a more thorough review of quantitative problems reviewed online versus FTF content.

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Lynn A. Fish, Ph.D. is a professor of management at Canisius College, Buffalo, NY, specializing in operations and supply chain management. Her research interests include innovative education, supply chain management, new product development, RFID, project management, quality management and sustainability.

Undergraduate Student Performance in Multi-Modal Educational Format

Lynn A. Fish, Canisius College, Buffalo, NY, USA

ABSTRACT

In a multi-modal environment where students could self-select their education method, differences in student performance exist. While average student performance for students who attended at least one class was better on graded assignments than online students; online students were not significantly different than other students on overall performance, homework and exams. Students who attended more than 75% of in-class opportunities performed significantly better on graded assignments than other students. The number of times that a student attended the face-to-face sessions appears to have an impact upon performance. Results have implications for education following the pandemic.

Keywords: Undergraduate students, performance, multi-modal

INTRODUCTION

During the pandemic, education dramatically changed as online education became the foundation for teaching at the collegiate level. While administrators argue that online learning performance is the same or superior to those in the traditional face-to-face (FTF) classroom (Allen & Seaman, 2013), others argue that online education does not replicate the traditional FTF classroom due to intrinsic differences (Bejerano, 2008). Several studies highlight the need for instructors to evaluate online activities to verify their relevance to student learning (e.g., Braunscheidel, Fish & Shambu, 2013; Fish, 2015, 2017; Santos, Hu & Jordan, 2014). During the pandemic, since some college students did not wish to have a completely online experience, institutions and instructors modified their courses to include in-class components. This study analyzes the impact of different educational formats - specifically online and online with FTF components on undergraduate business student performance. Specific questions include: (1) Did online students perform the same as FTF students on graded assignments? and (2) Did the number of times that a student attended a FTF session impact upon their performance?

In recent years, researchers have studied student performance in different educational formats – for example, online, hybrid, and 'web-facilitated' in comparison to traditional FTF courses. As technology changes, the definitions for these formats are 'blurred'. In this study, we refer to online learning as courses whereby everything is 100% online including all instructional and testing materials. Hybrid or blended courses offer a combination of FTF and online *instructional* time. 'Web-facilitated' courses include FTF classroom instruction supplemented by online materials such as the syllabus, PowerPoint presentations, taped lectures and handouts. Traditional FTF courses refer to courses taught in a FTF environment whereby all instructional and testing elements occur in the same physical environment.

Research regarding the effectiveness of different formats is mixed (e.g., Angiello, 2010, Cathoral et al., 2018, Ginns & Ellis, 2007; Love, Hodge, Grandgenett, & Swift, 2014; Metzgar, 2014; Olitsky & Cosgrove, 2014; Terry, 2007; Verhoeven & Rudchenko, 2013; Weldy, 2018). The frame of reference with these comparisons is in contrast to FTF courses. In a public institution's personal health course, student performance in web-facilitated (with FTF components) and hybrid course delivery formats were similar in spite of student preferences for web-facilitated courses with more FTF interactions (Cathoral et al., 2018). Contrastingly, in undergraduate managerial economics courses, student performance was lower in hybrid classes as compared to traditional FTF classes and results indicated that complex courses may not lend themselves to hybrid formats (Metzgar, 2014). Contrastingly, in an introductory economics course, there was no change in student performance (Olitsky & Cosgrove, 2014), but in an undergraduate microeconomics course, student performance in a hybrid section was weaker than in a FTF section (Verhoeven & Rudchenko, 2013). Yet another study over a decade ago, researchers found that student performance was higher for instruction that combined FTF lecture and online components than purely FTF instruction or purely online instruction (Angiello, 2010). In a study of graduate business student performance also performed over a decade ago, student performance on class assignments in FTF, online and hybrid formats were equivalent; however, students in online courses performed over 4% lower than FTF or hybrid students on the final exam (Terry, 2007).

Many of these studies involve different instructor comparisons or different student populations (typically across semesters or courses). The pandemic - and institutional requirements to offer a course as a 'multi-modal educational

experience' - offered a unique research opportunity as student performance in the *same class* with the *same instructor* but different educational formats can be compared. The institutions reference to a 'multi-modal educational experience' required all materials to be available online (due to potential quarantining requirements and COVID contraction) but encouraged FTF components for students who desired it. This multi-modal requirement changed the frame of reference from prior to studies being FTF to the online experience as the frame of reference. Specifically, this study seeks to explore the following hypotheses:

Online vs FTF Component Inclusion
Ho1: There is no difference between student performance for students taking the course solely online versus students who attend FTF sessions in addition to online.
H11: There is a difference between student performance for students taking the course solely online than students who attended FTF sessions in addition to online.

Number of Times FTF:
Ho2: There is no difference in student performance for students who attend more FTF sessions than students who attend fewer FTF sessions.
H12: There is a difference in student performance for students who attend all FTF sessions than students who attend fewer FTF sessions.

METHOD

At an AACSB-accredited University in the northeast due to the pandemic in the fall of 2020, the University required all classes to be offered as 'Multi-Modal'. By 'Multi-Modal', the University allowed students to self-select to attend classes in-person or online or both throughout the course, attendance could not be mandatory, and all materials were required to be available through online means. In other words, the courses were mainly online, but FTF elements were included. (Note this is a different form of hybrid than past studies as instructional elements were mainly online and supplemental elements were in the FTF classroom.) The University prides itself on being a 'teaching' University where class sizes are small (average 17), and the majority of classes prior to the pandemic were FTF - not online. In the fall of 2020 the *same instructor* taught two sections of a junior-level operations management course. Since the course involves both qualitative and quantitative material that students do not typically have experience with, students regard it as a complex and difficult course. The topics that the course taught included an introduction to operations management, process analysis, forecasting, project management, linear programming, inventory management, quality management, statistical process control, facility layout, Material Requirements Planning, aggregate planning, capacity planning, supply chain management, sustainability, and lean production. Twenty-two students enrolled in each of the two sections. For the first section, the in-class attendance ranged from 2 to 8 students at a session, while for the second section the in-class attendance ranged from 6 to 13 students at a session. (Five students withdrew from the course in the first section, but no one withdrew in the second section.) While the class 'normally' would meet twice a week for 75 minutes, to avoid quarantining requirements for everyone in the class per state Department of Health requirements, each in-class session was limited to less than 60 minutes. In keeping with state Department of Health requirements for contact tracing, while not a component of the class, the instructor recorded student attendance for in-class sessions. The instructor offered 18 in-class sessions to each section over the semester.

In keeping with the 'Multi-Modal' requirements, the instructor pre-recorded all lecture Power Point materials and posted them to the course Learning Management System (LMS). In keeping with University recommendations, the majority of videos averaged 7-15 minutes in length. (The instructor subdivided lectures by content to meet the time requirements. Some mathematical problems took longer than 15 minutes, and the instructor completed an entire math problem – regardless of how long it took – in a single videotape session.) The instructor provided a corresponding instructor developed handout for each lecture to students through the LMS. The handout required students to 'fill in' various sections as if they were sitting in class. Whether they attend the FTF class sessions or online, the instructor strongly recommended to a student that they listen to the lectures and fill in the notes. The instructor also provided suggested problems that corresponded to the textbook homework through the LMS. In order to keep the FTF classes 'value-added', the instructor did not repeat the lecture but gave a brief topic overview, and with the students, completed the suggested problems. All students – whether they attended a FTF class or not - were expected to listen to the videotapes, take notes and read the textbook. The in-class overviews were brief, lasting 5-10 minutes and in-class students could ask questions in real-time about the material. Since advanced technology was not available in the classrooms, online students did not attend the in-class session through any means and in-class sessions could not be

recorded. For online students, solutions to the suggested problems went 'live' following the FTF sessions, and they were encouraged to contact the instructor with any questions that they had.

In keeping with University requirements, student permission to use their performance was noted and obtained through the course syllabus. The graded course requirements included 9 online homework assignments (through a notable textbook publisher, 5% of overall grade), 9 quizzes that corresponded to the homework (23% of overall grade), and 3 non-cumulative exams (24% of overall grade each). The homework assignments were due the evening prior to the in-class quizzes and were graded by the textbook management system. A student had 3 attempts on each problem as well as '*hints*' and access to instructor assistance. In keeping with University requirements for testing during the pandemic, the quizzes and exams were only offered during the class time. Students who came to class could take the quiz in-class, while those online took it at the same time but online. Students had access to all materials during the quizzes and exams. FTF students did not have access to their cellphones or computers. The quizzes, each worth 10 points, consisted of multiple-choice questions, a short answer question and a math question on the relevant material. Quizzes were timed in the classroom and online with 20-minutes allowed before a 5-minute grace period began. Online quizzes did not allow students to go back to a question and were randomized by section. The instructor wrote all quiz and exam multiple choice, interpretation and short answer questions and did not use the pre-provided textbook materials (as solutions are available to students via alternative means). For math problems, online students were required to enter the mathematical answer into the textbox during the quiz, and once the quiz was over, submit their corresponding handwritten work to a Dropbox for credit. Credit for mathematical problems was only given if the Dropbox work corresponded to the answer in the textbox as the quiz was 'not an exercise in data entry into Excel'. With respect to the exams and given the state Department of Health 60-minute quarantining potential, *all* students were required to take the exams online. Each of the three exams were timed, consisted of 25 multiple choice, 4-5 short answer questions, an interpretation question, and 4-5 mathematical problems (where the numbers for each problem were randomized so the problems varied by student). The instructor pre-set all testing so a student could not go back to a question and randomized questions within each section (multiple choice, short answer, interpretation and math questions) between students occurred. The exam math question requirements were the same as for quizzes as students were required to insert the answer into the textbox and submit their handwritten work to a Dropbox for credit within 15 minutes of test completion. With respect to grading, the LMS graded the multiple-choice questions based upon the pre-selected correct response. The instructor graded all exam and quiz short-answer, interpretation and math problems, and awarded partial credit using a rubric for consistency between students.

ANALYSIS

Following completion of the course, the instructor analyzed student attendance at FTF sessions. As shown in Table 1, student attendance varied. A total of 16 students (out of 44) attended 11 or more FTF sessions, only 3 students attended 5 to 7 FTF sessions, and the rest of the students attended online only.

Table 1: Number of FTF Sessions Attended

Number of FTF Sessions Attended	Number of Students who Attended	Number of Sessions Attended	Number of Students who Attended
18	0	9	0
17	3	8	0
16	4	7	1
15	2	6	1
14	2	5	1
13	1	4	0
12	2	3	0
11	2	2	0
10	0	1	0

To address the basic question whether there was a difference in student performance given attending any FTF sessions or not, student performance on the graded material for students who took the class solely online versus those who attended at least one session FTF was analyzed using a two-tailed t-test. Twenty students completed the course completely through online means, while 19 students attended at least 1 session. As shown in Table 2, analysis revealed that student overall performance was slightly significant (p=.06) and quiz performance (p=.01) was significantly

different between FTF and online students as FTF students performed better than online students on quizzes. While the average student performance for those who attended at least one in-class session was better than online students on homework and exams, a statistically significant difference in their performance did not exist.

Table 2: Face-to-Face vs Online Student Performance

Student Performance	FTF Average	Online Average	T-test
Overall	81.34	76.08	.06 **
Homework	93.41	90.31	.31
Quizzes	89.17	77.96	.01 *
Exam I	74.72	69.82	.19
Exam II	81.07	77.52	.25
Exam III	78.21	75.70	.51
Exams All	78.00	74.49	.21

*p ≤ .05, ** p ≤ .10

As shown in Table 1, there is a definite gap in attendance between the number of students who attended in-class sessions 7 times (which corresponds to 38.9 % attendance) and 11 times (which corresponds to 61.1% attendance). Given the course structure, one may surmise that students who attended less than 8 times completed the majority of their learning online. As shown in Table 3, comparing student performance for students who attended FTF class 7 or fewer times (note that this includes online students) with those that attended FTF class more than 10 times reveals statistically significant differences in overall performance (p=.02), quizzes (p=.00), and exam II (p=.05). (Note no students attended 8 to 10 sessions of the course in person.) The overall average on all exams (p=.06) and exams I (p=.07) were slightly significantly different between the groups. Homework and exam III was not significantly different between the two groups. Regardless of the graded item – and although it's not always statistically significant, FTF students who attended more than 10 times performed better than students who attended 7 or fewer FTF sessions on all graded items. The number of times that a student attended the FTF sessions appears to have an impact upon their performance.

Table 3. FTF More than 8 Times vs Online & FTF Less than 8 Times Student Performance

Student Performance	Average FTF > 11 times	Average FTF<8 & OL	T-test
Overall	82.32	76.09	.02 *
Homework	92.64	91.25	.64
Quizzes	89.93	78.90	.00 *
Exam I	76.03	69.55	.07 **
Exam II	82.59	76.93	.05 *
Exam III	78.88	75.95	.35
Exams All	79.17	74.14	.06 **

*p ≤ .05, ** p ≤ .10

To explore the impact of student attendance further, students were grouped into three groups: attendance at more than 75% of in-class sessions (14 or more FTF sessions; Group #1), less than 75% attendance at in-class sessions (1 to 13 FTF sessions; Group #2), and online only (Group #3). There were 11 students who attended 14 or more sessions, 8 students who attended 1 to 13 sessions, and 20 students who did not attend any FTF classes. Various statistical testing results are in Table 4. Comparing students who attended FTF 14 times or more with solely online students (Group #1 v Group #3) showed significant differences in overall (p=.01), quiz (p=.00), and all exams (p=.03) – and particularly exam II (p=.03), as well as slightly significant for homework (p=.07). Comparing students who attended FTF 14 times or more with students who attended 13 FTF sessions or less (Group #1 v Group #2) was statistically significant for overall (p=.02), quizzes (p=.05), and all exams (p=.03) – particularly exam II (p=.02) and exam III (p=.04). Interestingly, comparing students who attended 13 or fewer session with online students (Group #2 v Group #3) did not reveal any significant differences between the groups; however, quizzes were slightly significant (p=.07). Since the differences between students coming to class 13 times or less and online students was insignificant, comparison between the students who came to class 14 times or more and the other two groups was performed. Results demonstrate a significant difference on every performance measure except exam I.

Table 4: Student Performance FTF 14 Times or More vs FTF 13 Times or Less vs Online

Student Performance	Average Group Performance			T-Test			
	#1 (14+ FTF)	#2 (1 – 13 FTF)	#3 (OL)	#1 v #3	#1 v #2	#2 v #3	#1 v #23
Overall	84.23	77.36	76.08	.01 *	.02 *	.68	.00 *
Homework	95.64	90.34	90.31	.07 **	.20	.99	.04 *
Quizzes	91.62	85.8	77.96	.00 *	.05 *	.07 **	.00 *
Exam I	76.69	72.01	69.82	.10	.30	.63	.10
Exam II	84.84	75.89	77.52	.03 *	.02 *	.67	.01 *
Exam III	81.72	73.39	76.14	.11	.04 *	.46	.05 *
Exams All	81.08	73.76	74.49	.03 *	.03 *	.82	.01 *

*$p \leq .05$, ** $p \leq .10$

DISCUSSION

As noted in the literature review, research regarding the effectiveness of different formats is mixed and still accumulating. For most prior studies, the FTF environment was the frame of reference for comparison (e.g. Angiello, 2010, Cathoral et al., 2018, Ginns & Ellis, 2007; Love, Hodge, Grandgenett, & Swift, 2014; Metzgar, 2014; Olitsky & Cosgrove, 2014; Terry, 2007; Verhoeven & Rudchenko, 2013). The pandemic and radical change in course delivery methods offered the opportunity to analyze delivery formats from another perspective. This study adds to this research stream as online and online with FTF components are studied for a complex and difficult undergraduate business course. Only a slight significant difference on overall student performance between students taking the course solely online versus students with some additional FTF components exists. This result is different than the study over a decade ago that showed students performed better when online components were added to a FTF lecture than in pure FTF or pure online (Angiello, 2010). Notice that the point of reference is adding online to FTF instead of FTF to online as in this study. The general results are similar to another older study that showed no significant differences between FTF, online and hybrid in graduate business student performance, and students in FTF or hybrids performed better than online students on a final exam (Terry, 2007).

Hypothesis #1 was - and was not - held. While students who attended some sessions performed better on all graded material, the difference was not statistically significant. Quizzes were statistically significant. While the questions were the same, the method of taking the quiz was different. In-class quizzes were static – and what most students were accustomed to. FTF students could move between questions where those online were limited in their ability to move back to a question (to reduce cheating). However, as noted before, due to time constraints and Department of Health requirements (discussed previously), all students took the exams online – and experienced the same testing medium. While a statistical significant difference in their performance between the two groups did not exist, those students who experienced some FTF elements performed better on average than their online counterparts on exams. Therefore, the difference cannot be solely attributed to the different test taking method.

Our analysis explored the impact of a student attending more FTF sessions, and hypothesis #2 was not held for most performance metrics as students who attended more than 10 sessions FTF performed significantly better on overall performance and in particular, quizzes (and a slight significance on exams). Merely attending just a few FTF sessions did not significantly impact upon student performance.

Further analysis that divided the students into the three groups highlighted the significant impact attending more FTF sessions had on student performance. Results showed that the online group and lower attendance groups were very similar in their performance. *In other words, if a student did not come to class 'enough', there was not a positive benefit of coming to class over staying online completely.* This result implies that there is a 'threshold' of attendance that needs to be overcome for students to benefit from FTF sessions, and students adjust to teaching methods over time. For FTF students, those who attended class 14 times or more (Group #1) performed significantly better than students who attended less than 14 times (Group #2) on everything but homework and Exam I. With respect to Exam I, for many mainly FTF students Exam I was their first online testing experience and they struggled with the experience. By Exam II and III, students who attended more appear to 'reap' the benefits of the FTF experience as they performed significantly better than those that attended FTF less. Students who attended 14 or more times (Group #1) performed significantly better than other students (Groups #2 and #3) on graded assignments - except Exam I.

Again, this result supports the difficulties that the students who attended 14 or more times may have experienced in the initial online testing format. Interestingly, homework was only significantly different between the groups when comparing the results for students who attended 14 or more FTF sessions versus the other students. Homework was essentially the same for all students as it was online, encouraged mastery, allowed for hints, and other sources to solve the problems. A potential conclusion is that through reviewing the suggested problems in the FTF sessions, students who came to the majority of classes *learned from the experience*. In this study, we divided and analyzed the results at two different FTF attendance points: (1) less than 8 and more than 11, and (2) less than 14 versus 14 or more. Student performance changed between these two studies as more graded assignments became significantly different between the two groups. Therefore, there appears to be a difference by attending more sessions but there is a question as to what *specific number* of FTF classes a student should attend that will make a difference in performance. Given the dataset size, there simply isn't enough data to firmly establish a specific attendance number. However, clearly there is an aspect of attending FTF that has a positive overall effect – particularly for students who come to more than 75% of available sessions.

CONCLUSIONS

While the general results do not support a significant difference between adding FTF components to online classes to improve student performance, deeper analysis shows significant differences as discussed in this study. This study demonstrates the strong impact that 'attendance' requirements for FTF components into mainly online classes can have on student performance. It is important to understand that the student body selected the School originally for its strong in-class traditional teachings, and additionally students self-selected their educational method for this course during the pandemic. For this student body, students performed better when they attended a significant portion of in-class sessions. This type of education is what the majority of the students have been educated throughout their academic career. These results speak to the idea that for this student body has not experienced and learned to be educated through online education yet. This result may change in the future as they experience more online education. As the pandemic subsides, education will need to change to meet the current student body's perceptions and requirements regarding educational components. Going forward, instructors and institutions need to address what methods education will use in the 21st century.

Limitations.

Due to the small class sizes, while meeting the general threshold of having at least 30 data points in order to draw relevant conclusions, when subdividing the dataset further, it becomes difficult to interpret the results due to the small subset sizes. Replicating this study requires much larger classes to draw deeper conclusions.

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Lynn A. Fish, Ph.D. is a professor of management at Canisius College, Buffalo, NY, specializing in operations and supply chain management. Her research interests include innovative education, supply chain management, new product development, RFID, project management, quality management and sustainability

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Michael A. Roberto is the Trustee Professor of Management at Bryant University. His research interests focus on decision making, creative problem solving, and team dynamics.

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Manuscript Guidelines, Submission and Review Process

TOPIC AREAS (BUT NOT LIMITED TO THESE):

- Course design – current courses, new courses, new trends in course topics
- Course management – successful policies for attendance, homework, academic honesty …
- Class material
  - o Description and use of new cases or material
  - o Lecture notes, particularly new and emerging topics not covered effectively in textbooks
  - o Innovative class activities and action-learning – games, active learning, problem based
- Major or emphasis area program design that is new or innovative.
- Assessment – all aspects including AACSB and university level assessment strategies and programs
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- Faster delivery methods are available for US and international delivery. Contact the editor for a specific pricing.
- All publication fees should be remitted within 10 business days of acceptance, if possible.
- If you decide not to publish your paper with BEI Journal after submitting payment, we will refund publication fees less $200 to cover costs of review and processing.
- Cancellation cannot occur after the paper has been formatted into the final printer's file.

Manuscript Style Guide and Example

An example is provided following these instructions.
This style guide represents style guidelines in effect for future issues, but always check for updates online.
Authors are responsible for checking for correct grammar, construction and spelling. Authors are also responsible for formatting pictures, tables, and figures such that a pdf black and white file sent to the publisher will reproduce in a readable manner.

General Setup:

- All fonts other than exceptions noted below: Times New Roman. 10 point for text. Other sizes as noted below
- Margins: 1 inch on all sides of 8½x11 inch paper size.
- No headers or footers.
- Absolutely no footnotes or endnotes via footnote or endnote formatting. For footnotes or endnotes, place a number of the footnote in the proper location as a superscript. Then at the end of the paper or bottom of the page, add the footnote as text with a superscript number to correspond to that footnote.
- Page numbering bottom centered.
- No section breaks in the paper.
- No color, including url's. Format to black. No color in tables or figures. Use shading if necessary.
- All pages must be portrait orientation. Tables and figures in landscape orientations should be reformatted into portrait orientation.
- All paragraphs should be justified left and right, single spaced, in 10 point Times font, no indent on first line, l line between each heading and paragraph.
- One line between each paragraph.

Titles, Authors, and Headings:

- **Title centered 14 point bold**. One line between title and author's name.
- Authors: centered, 12 point. Name, affiliation, state, country.
- One line space to **ABSTRACT** (title 10 point, bold, all capitalized, aligned left; text of abstract 10 point, no bold)
- After **ABSTRACT**, one line space, then **Keywords**. Followed by one line space to first major heading.
- **HEADINGS, MAJOR**, 10 point, bold, all capitalized, aligned left.
  The specific headlines will be based on the content of the paper, but major sections should at a minimum include an abstract, keywords, introduction, conclusion, and references.
- **Sub-headings**: 10 point, bold, first letter capitalized, no line to following paragraph. Align left.
- *Third level headings: Italic*, 10 point, first letter capitalized, no line to following paragraph. Align left.
- **Keywords:** heading: 10 point, bold, first letter capitalized, no line to following paragraph. Align left. Your list of keywords in 10 point, no bold.

Tables, Figures and Graphs:

- All fonts 10 point.
- Numbered consecutively within each category. Table 1, Figure 1 etc.
- Title: 10 point, bold, left justify title, one space, then the table, figure, etc.
- Example: **Table 1: Statistical Analysis**

References:

- APA format when citing in the text. For example (Smith, 2009).
- References section: 8 point font, first line left margin, continuation lines 0.25 inch indent. Justify left and right. No line spacing between references. List alphabetically by first author.
- Specific references: Last name, First initial, middle initial (and additional authors same style) (year of publication in parentheses). Title of article. *Journal or source in italics.* Volume and issue, page number range.
- Example: Clon, E. and Johanson, E. (2006). Sloppy Writing and Performance in Principles of Economics. *Educational Economics*. V. 14, No. 2, pp 211-233.
- For books: last name, first initial, middle initial (and additional authors same style) (year of publication in parentheses). *Title of book in italics.* Publisher information.
- Example: Houghton, P.M, and Houghton, T.J. (2009). *APA: The Easy Way!* Flint, MI: Baker College.

Example (note that this example represents a change from previous style guides)

Evidence to Support Sloppy Writing Leads to Sloppy Thinking

Peter J. Billington, Colorado State University - Pueblo, Colorado, USA (12 point)
Terri Dactil, High Plains University, Alberta, Canada

ABSTRACT (10 point, bold, all capitalized, left justified)

(text: 10 point Times font, no indent, justified, single space, 150 words maximum for the abstract)
The classic phrase "sloppy writing leads to sloppy thinking" has been used by many to make writers develop structured and clear writing. However, although many people do believe this phrase, no one has yet been able to prove that, in fact, sloppy writing leads to sloppy thinking. In this paper, we study the causal relationship between sloppy writing and sloppy thinking.

Keywords: sloppy writing**,** sloppy thinking **(10 point, bold title, first letter capitalized, left justified).**

INTRODUCTION (10 point, bold, all capitalized, left justified).

The classic phrase "sloppy writing leads to sloppy thinking" has been used by many to make writers develop structured and clear writing. However, since many people do believe this phrase, no one has yet been able to prove that in fact, sloppy writing leads to sloppy thinking. Is it possible that sloppy writing is done, even with good thinking. Or perhaps excellent writing is developed, even with sloppy thinking.

In this paper, we study the writing of 200 students that attempts to test the theory that sloppy writing leads to sloppy thinking.

PREVIOUS RESEARCH

The original phrase came into wide use around 2005 (Clon, 2006), who observed sloppy writing in economics classes. Sloppy writing was observed in other economics classes (Druden and Ellias, 2003).

RESEARCH DESIGN

Two hundred students in two business statistics sections during one semester were given assignments to write reports on statistical sampling results. The papers were graded on a "sloppiness" factor using…

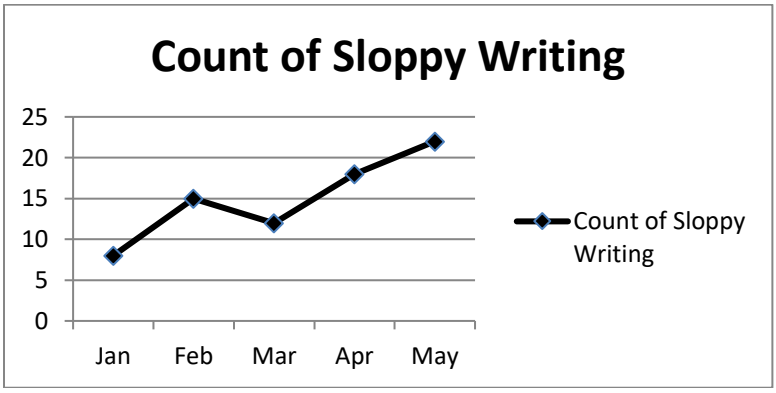
Data Collection (Sub-heading, bold but not all caps, 10 point, aligned left, bold, no line after to paragraph)
The two hundred students were asked to write 2 short papers during the semester…

Data Analysis(Sub-heading, bold but not all caps, 10 point, aligned left, bold, no line after to paragraph)
The two hundred students were asked to write 2 short papers during the semester…

DISCUSSION

The resulting statistical analysis shows a significant correlation between sloppy writing and sloppy thinking. As noted below in Figure 1, the amount of sloppy writing increases over the course of the spring semester.

Figure 1: Sloppy Writing During the Semester



The count results were compiled and shown in Table 1 below.

Table 1: Counts of Good and Sloppy Writing and Thinking (bold, 1 line after to table, left justify)

	Good Thinking	**Sloppy Thinking**
Good Writing	5	22
Sloppy Writing	21	36

*-Indicates significance at the 5% level)

As Table 1 shows conclusively, there is not much good writing nor good thinking going on.

CONCLUSIONS

The statistical analysis shows that there is a strong relation between sloppy writing and sloppy thinking, however, it is not clear which causes the other…

Future research will try to determine causality.

REFERENCES (title10 point, all caps, bold, align left, one line to first reference)
(1line spacing) (All references 8 point, indent second line 0.25 inch, justify left and right)

Clon, E. (2006). Sloppy Writing and Performance in Principles of Economics. *Educational Economics*. V. 14, No. 2, pp 211-233.

Devad, S. and Flotz, J. Evaluation of Factors Influencing Student Class Writing and Performance. *American Journal of Farming Economics*. V. 78, Issue 3, pp 499-502.

Druden, G. and Ellias, L. (1995). *Principles of Economics*. New York: Irwin.

(short bio section optional, can run longer than these examples; removed before sent to reviewers)

Peter J. Billington, Ph.D., is a professor of operations management at Colorado State University – Pueblo. His research interests include lean six sigma and innovative education.

Terri Dactil, Ph.D., is a professor of business communication in the College of Business at High Plains University, Alberta, Canada. His research interests include instructional methods to improve student communication skills.

Endnote: (do not use word footnote or endnote formatting to accomplish this; see comments above)