
A Comparison of Student Learning in an Introductory Logic Circuits Course: Traditional Face-to-Face vs. Fully Online

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- The Research Question:

Can the same level of student understanding be achieved in an introductory logic circuits course when delivered fully online compared to a traditional, live-taught delivery?

- The Experiment: “EE261 – Introduction to Logic Circuits” (required sophomore-level course)
 - Material developed to support both live and online versions.
 - Fall 2010, the course was delivered using a traditional, **live taught lecture**.
 - Spring of 2011, the course was delivered **fully online** using *Camtasia* Relay Videos in lieu of the live taught lectures and using Desire To Learn (DTL) as the online platform.
 - Every other component of the courses was left identical in order to see how effective the online delivery of the course was compared to the traditional live taught version.



- **Learning Outcomes for “EE261 – Introduction to Logic Circuits”**

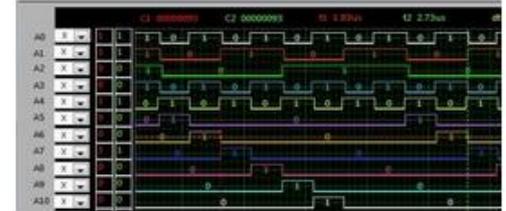
At the end of this course the student should be able to:

- 1) Understand the difference between analog and digital signals.
- 2) Accomplish number system conversions (decimal, binary, octal, hexadecimal).
- 3) Understand how digital logic gates are created and interface with each other.
- 4) Design, analyze, and minimize combination circuits using properties of Boolean algebra and Karnaugh Maps.
- 5) Understand the concepts of hardware description languages and the modern digital design flow.
- 6) Understand operation of basic combinational logic, medium scale integrated circuits (decoders, encoders, multiplexers, demultiplexers and adders) and be able to describe and simulate them with a hardware description language.
- 7) Design and analyze basic sequential logic circuits, specifically finite state machines
- 8) Be familiar with basic concepts of programmable logic and information storage devices.



- **ABET Outcomes for “EE261 – Introduction to Logic Circuits”**

This course is used as an indicator for ABET outcome “o”) ***An ability to design digital systems using modern design tools*** for both EE and CpE majors.



The score for the outcome is determined by averaging 5 graded components of the course:

Module 5 Quiz – a quiz testing the student’s understanding on how computer aided engineering tools are used in the modern digital design flow based on HDLs and synthesizers.

Module 6 Homework #1 –students describe a set of basic combinational logic gates using VHDL and simulate their operation using an industrial grade logic simulator.

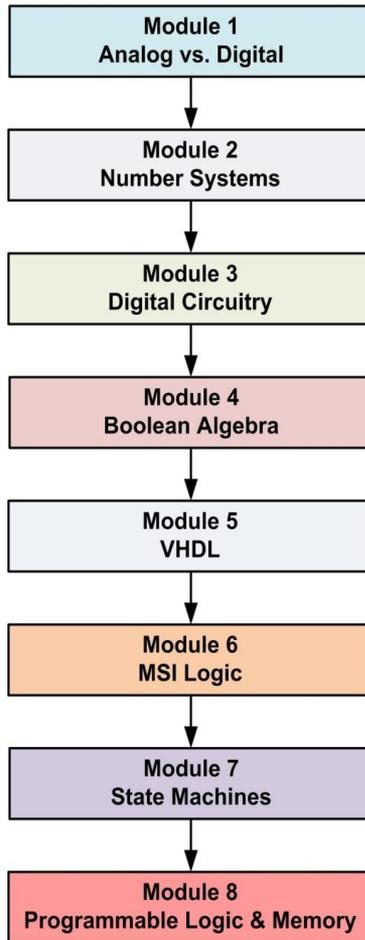
Module 6 Homework #2 –students describe a decoder and a multiplexer using VHDL and simulate their operation using an industrial grade logic simulator.

Module 7 Homework #1 –students describe the operation of a sequential storage device (a D-flip-flop) and how it can be used as a clock divider using VHDL and simulate the operation using an industrial grade logic simulator.

Module 7 Homework #3 –students describe binary and gray code counters using structural VHDL and simulate their operation using an industrial grade logic simulator.



- **Eight modules were created to meet the learning objectives**



- Each module contained:

- more specific learning objectives
- textbook reading assignments
- PowerPoint slides developed by instructor(s)
- lectures (either live or recorded)
- practice problems, ungraded
- weekly homework assignments (1-3 sets), graded
- weekly discussion assignments (1-3 sets), graded
- an end of module quiz, graded (30% of grade)



- **At the end of each module, students completed a timed quiz**
 - 1 to 3 multiple choice questions on key concepts of the module.
 - Once the student started the quiz, they had 60 minutes to complete it.
 - The multiple choice quizzes were auto graded by the D2L system.
 - Students received their scores immediately upon submission.
 - Students could see the quiz solutions after the due date.



- **During finals week, a comprehensive final exam was given.**
 - 40 multiple choice questions on key concepts of the course.
 - Once students started the exam, they had 120 minutes to complete it.
 - The students could start the exam any time after the last day of class until the end of the scheduled final exam time.
 - The multiple choice exam was auto graded by the D2L system.
 - Students received their scores immediately upon submission.
 - Students could not see the solutions.



Fall 2010 (live)

Delivery: Traditional, 50 minute live lecture on M/W/F.

Combination of PowerPoint slides and writing on the whiteboard.

Spring 2011 (online)

Delivery: Camtasia Relay Capture, 1-3 videos per M/W/F lecture, videos 10-40 minutes in length.

Videos consisted of instructor talking over PowerPoint slides and working examples using a drawing program

Windows Media Player

Now Playing Library Rip Burn Sync

Logic Minimization

Karnaugh Map Minimization

AB	00	01	11	10
0	0	1	0	0
1	1	0	1	1

The circle covers 1 cell
the circle covers:
- where A=0, so the literal is A'
- where B=1, so the literal is B
- where C=0, so the literal is C'
- The product term for this circle is 'A'B'C'

The circle covers 2 cells
the circle covers:
- where A=1, so the literal is A
- where B=0 and 1, exclude the literal
- where C=1, so the literal is C
- The product term for this circle is 'A'C'

The circle covers 2 cells
the circle covers:
- where A=0 and 1, exclude the literal
- where B=0, so the literal is B'
- where C=1, so the literal is C
- The product term for this circle is 'B'C'

our final minimized SOP expression is
 $F = A'B'C' + AC + B'C$

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07:02



Fall 2010 (live)

- **Students Completing Course:** **26**
- **Major Breakdown**
19 EE, 3 CpE, 2 CS, 1 other
- **Level Breakdown (by credits)**
5 FR, 13 SO, 5 JR, 3 SR
- **GPA Breakdown:**
Course Average: **2.94 / 4.00**
- **Calculus I Preparedness**
Passed Calc 1: 21 (81%)
Co-Enrolled in Calc 1: 3
Not Taken Calc I: 2

Spring 2011 (online)

- **Students Completing Course:** **35**
- **Major Breakdown**
17 EE, 7 CpE, 5 CS, 6 other
- **Level Breakdown (by credits)**
9 FR, 13 SO, 6 JR, 7 SR
- **GPA Breakdown:**
Course Average: **3.02 / 4.00**
- **Calculus I Preparedness**
Passed Calc 1: 32 (91%)
Co-Enrolled in Calc 1: 0
Not Taken Calc I: 3



- GPA when looking at all students in each group is:

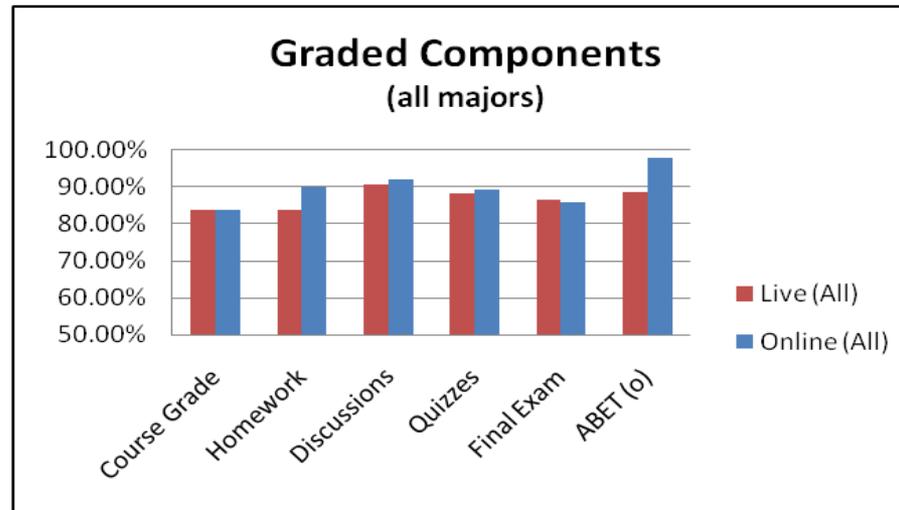
Live = 2.94 / 4.00

Online = 3.02 / 4.00

$\Delta = 2.7\%$

- A two-sample t-test showed no significant difference in the grades of these two groups; however, the samples were relatively small, so the final results should be tempered with the fact that the online group's incoming overall gpa was slightly higher.

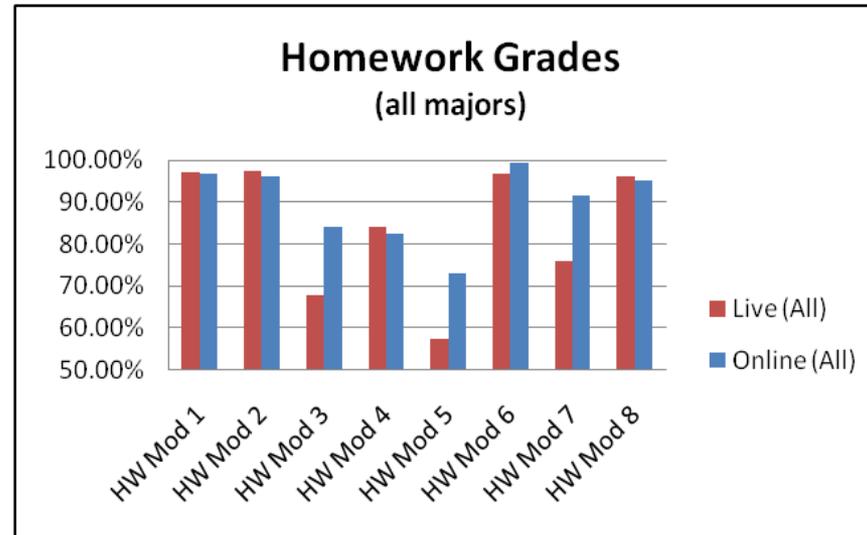




Summary

- For all course graded items, the online course scores were either statistically equivalent or better than the live course scores.
- The largest difference was in the ABET outcome scores: the online course was significantly higher in a two-sample t-test. This could be due to having access to a video that could be viewed repeatedly while completing the homework

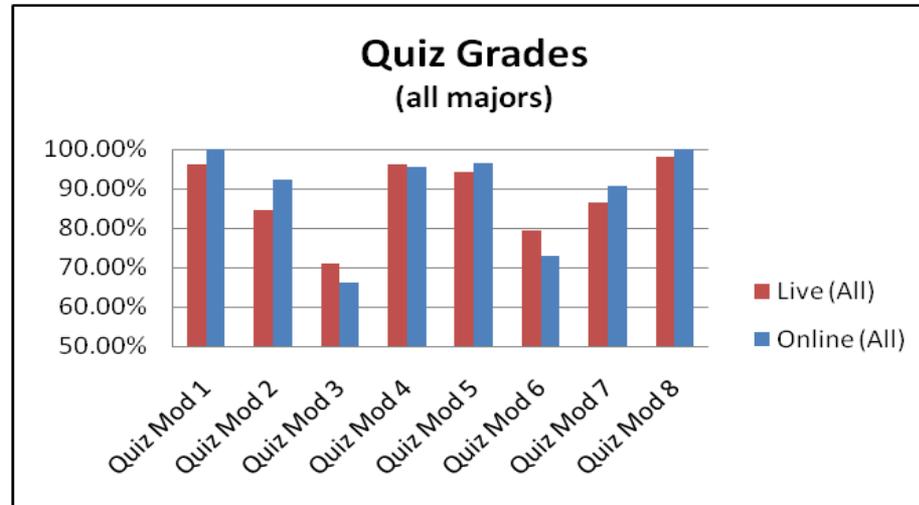




Summary

- The homework grades for Modules 3, 5, and 7 were significantly higher for the online group (according to a two-sample t-test at $p = .05$).

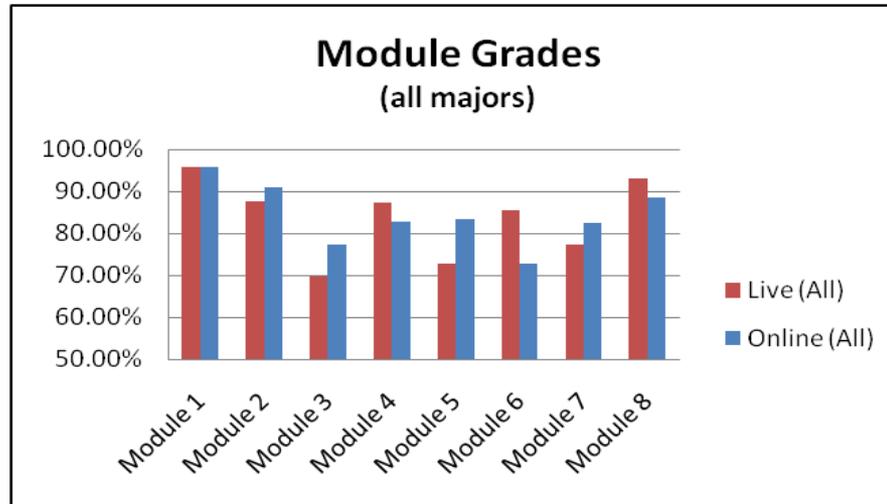




Summary

- No significant differences were found between the groups on the module quizzes.





Summary

- Module grades include homework and quizzes that aren't submitted as 0's.
- Two-sample t-tests showed that the online group scored significantly higher on Module 5 (at $p = .05$) and the face-to-face group scored significantly higher on Module 6 (at $p = .05$).
- The live-taught course appears slightly better at explaining synthesis of digital circuitry & analysis of analog circuitry topics.
- The online course appears slightly better in explaining the use of CAE tools (Module 5), perhaps due to having a tutorial resource that can be accessed at the student's discretion.



Course evaluations provide insight into the student's perception of the course.

Fall 2010 (live)

Spring 2011 (online)

2.1) Overall Instructor Rating

3.1) Mastery of subject matter

3.2) Organization of course

3.3) Clarity of presentation

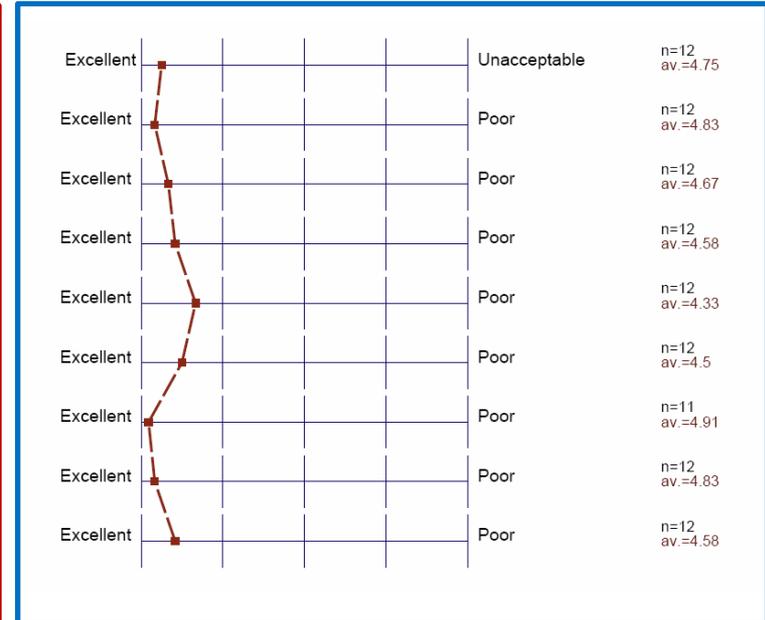
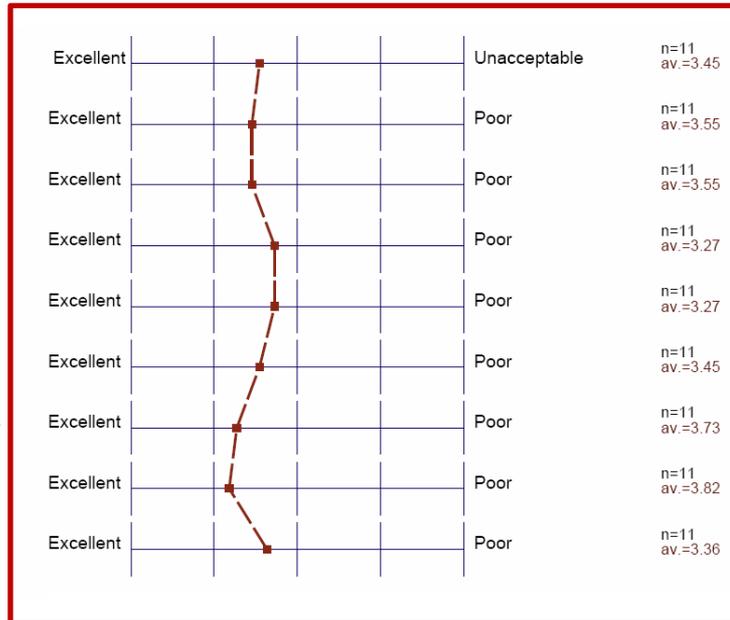
3.4) Stimulation of interest

3.5) Availability for assistance

3.6) Impartiality on grades and exams

3.7) Concern for students

3.8) Overall effectiveness



- **An introductory logic circuits course was taught with the exact same material while altering only the delivery style (live vs. online).**
- **There were minimal differences between the level of performance between the two delivery styles.**
- **The live-taught course appears slightly better at explaining synthesis of digital circuitry & analysis of analog circuitry topics.**
- **The online course appears slightly better in explaining the use of CAE tools, perhaps due to having a tutorial resource that can be accessed at the student's discretion.**

