



Moving the Science of Learning From Face-to-Face to Online

Entering the 2019–2020 academic year, my Principles of Microeconomics and Principles of Macroeconomics classes incorporated the science of learning in a face-to-face format. These classes had an enrollment of 25 students and were taught at a small liberal arts college. In response to the COVID-19 pandemic, the courses were altered from a face-to-face format to a 100% online format. This paper explains the incorporation of the science of learning literature into a Principles of Economics course and the transition to a 100% online format with special attention to a continuation of the instructional tools from the science of learning.

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1. Introduction

William E. Becker and Michael Watts (Becker & Watts, 1995) describe many of the teaching innovations available in economics instruction. Over the years, the authors follow up with economics instructors and find that most U.S. economists are not implementing the innovations (technological and delivery/learning styles) in teaching (Becker & Watts, 1996). In the spring of 2000, Becker and Watts conducted another national survey and found that the “dominant picture of the U.S. undergraduate economics teacher continues to be a male... who lectures to a class of students as he writes text, equations, or graphs on the chalkboard, and who assigns students reading from a standard textbook” (Becker & Watts, 2001). In other fields, instructors have adopted the tools from the science of learning literature to increase the level of learning in their classes. Entering the 2019–2020 academic year, my Principles of Microeconomics and Principles of Macroeconomics courses were constructed to leverage the tools from the science of learning in a face-to-face classroom format. These courses enrolled 25 students each and were taught at a small liberal arts college. The COVID-19 pandemic changed the instruction format from face-to-face to 100% online (everything else about the classes remained the same). This paper describes the incorporation of the science of learning literature into my Principles of Economics classes and the transition to a 100% online format.

2. Using the Science of Learning in a Face-to-Face Classroom

Entering the 2019–2020 academic year, my Principles of Microeconomics and Principles of Macroeconomics courses emphasized the science of learning, focusing on work by James A. Lang (2016), Joshua R. Eyler (2018), and Pooja K. Agarwal and Patrice M. Bain (2019). The science of learning is a set of research literature that studies how humans learn and remember concepts. This research is conducted by learning scientists and includes neuroscientists and cognitive psychologists. I choose to implement the lessons learned in the science of learning to maximize learning in my courses. This established literature provides empirical evidence on which approaches maximize student learning and why. The tools from the science of learning incorporated for a face-to-face class format and altered for the 100% online format are retrieval, connections, practice, motivation, and a growth mindset. For each tool, I will outline some of the research for the tool and how the tool is implemented in a face-to-face format.

A. Retrieval Practice

When students first encounter new material, they encode and store the new information—the act of retrieving transfers that information from storage to being able for us to use. Roediger and Karpicke (2006) conduct a study to examine the impact of rereading a passage versus being asked to write down everything they can remember. The group that reread the material recalled more of the information than those who were asked to write down everything when quizzed on the material five minutes later. However, the groups’ performances switched when they were quizzed a week later, offering evidence that students who are asked to actively retrieve information remember material for a longer time. In a face-to-face course, you can start each class with a retrieval practice question based on the assigned reading for the day. In my face-to-face classes, the construction of the questions changes throughout the term from a simple recollection of vocabulary terms to asking students to write down everything they recall about the reading (brain dump). As Butler and Roediger (2007) find, the nature or design of the retrieval activity can impact the ability of students to recall information. When considering a retrieval activity, I have the students actively creating their answers, such as defining a term or using it in a sentence, rather than selecting a correct answer like a multiple-choice quiz.

B. Connections

Ambrose and Lovett (2014) note that the amount of knowledge that students bring with them to a class plays a crucial role in learning the material. In a face-to-face course, you can use the end of a class period to ask your students to write down what they know about concept X (a concept that you will cover in upcoming classes). This allows you to see what students think about the concept and allows you to reference those ideas as you cover the concept in class. Most instructors who have taught for years probably incorporate this teaching tool by anticipating student misconceptions observed year after year in a given course. However, when you solicit the information directly from your class, you can cover the specific level of knowledge that they have before covering it in the course.

C. Practice

I ran my first marathon at age 28 and finished in approximately four and a half hours. At the age of 40, I was able to finish a marathon in three hours and fifty-five minutes. The main factor contributing to a faster time was the incorporation of practice. Willingham (2009) notes that people can improve their performance on a cognitive task through practice. In a face-to-face class, you can break students into groups and have them collaborate to answer a few questions. For example, if the students have already covered supply, demand, and equilibrium, you can ask them to illustrate a market in an initial equilibrium and then illustrate and explain what happens if some factor changes. You can walk around the classroom and provide feedback in real-time as the students work through the problems. Then, bring the students back together at the end and focus on the problems or parts of particular problems that appear to be causing the most confusion or the lowest level of understanding. As with the previously mentioned retrieval practice, it is important to note that your objective should not be to assign many multiple-choice questions but to select a few problems where students can engage the material and achieve a greater level of understanding. Using multiple-choice questions can promote the selection of an answer versus creating an answer that creates greater engagement.

D. Motivation

One of the aspects of teaching that has always been problematic for me is being able to motivate students to learn. Early in my teaching career, I would attempt to motivate my students by making the material more entertaining or apply them to pop culture. Joshua Eyler (2018) tells a wonderful story about Donald Saari, a mathematician at the University of California, Irvine. Saari attempts to join his students in an exploration of a topic and collectively building connections to material together. In a face-to-face course, I still rely somewhat on storytelling, but I also attempt to motivate my students when providing feedback on their in-class practice questions and when they provide answers to the class. You can emphasize the parts of the problems that they are getting correct. For the parts that they are not answering correctly, you can remind them that one of the best ways to learn is from failure and that getting something wrong initially can increase our ability to remember the concept in the future. Finally, you can get to the classroom a few minutes early to share personal stories of learning that can help motivate students and remind them to continue to focus on the future of the course and opportunities to improve.

E. Growth Mindset

When entering college, my SAT Verbal scores were below average for first-year students, and my SAT Math scores were above average. Knowing that the verbal scores were below average, I dedicated an enormous amount of time working with my first-year writing professor. If I had a fixed mindset (one that thinks the level of ability or knowledge is fixed) of being a poor reader and writer, then I would have failed to improve and would have been much less successful in college and life. Instead, the growth mindset (a mindset that thinks the level of

ability or knowledge can change) allowed me to increase my skills over time. Mueller and Dweck (1998) find that students who are praised for their effort outperform students who are praised for their natural ability. In a face-to-face course, I provide individual feedback that praises the process of thinking rather than a right or wrong response. Also, when a student is providing an incorrect answer, I challenge them to think of it in another way or answer a follow-up question so that they can find the flaw in the initial statement. I also share stories like the one at the start of this paragraph in an attempt to show my students when I have used a growth mindset and how it has helped me over time.

In my face-to-face environment, I structured my Principles of Economics courses centering on the science of learning literature. For each of my classes, the structure, assignments, and day-to-day operations incorporated teaching tools backed by empirical evidence to support greater learning. The introduction of the COVID-19 pandemic caused the structure of the courses (only the course delivery) to change. In the following section, I describe the adjustments that I made to change my classes from face-to-face to 100% online.

3. Using the Science of Learning in the 100% Online Format

In March 2020, most educators had a few days to a week to change the format of their classes. For Fall 2020, most of us had weeks to months to consider how to best create our courses. I chose to use Zoom for synchronous sessions for my classes. This section presents the changes in Principles of Economics courses focusing on retrieval, connections, practicing, motivation, and a growth mindset.

A. Retrieval Practice

In the face-to-face format, my Principles of Economics courses began each day with a short activity that addresses the assigned reading. When transitioning to a 100% online format, I changed to assigning Learning Curve activities for textbook chapters in Achieve (a product from MacMillan Publishers). Learning Curve provides an initial test of concepts from a chapter reading. A student earns the most points for a question by answering it correctly. However, the student can attempt to answer the question correctly after an incorrect answer and still earn some points. After a few incorrect responses, the student is forced to move to a different question to earn points. In the Learning Curve, you can set a number of points to earn to complete the activity. This allows the students to practice the recall of information without encountering a grade penalty. If you miss a question, you can answer another one to earn points, so a student would only be “penalized” with having to spend more time with the material. An instructor could create similar opportunities for students by issuing a question and informing them of what they did incorrectly but allowing them to attempt a problem again to earn a set number of points. The use of the Learning Curve software creates this opportunity with minimal effort from the instructor. Other publishers may have similar software available, so I encourage readers to check with their publishers. So far, my students’ completion percentage has been higher than the in-class recall scores, and anecdotally, the students have reported liking being able to test themselves in a low-stakes manner before they are quizzed or tested.

Another tool to allow retrieval practice is to use the Zoom polling feature. Derek Bruff (2019) and Dan Levy (2020) offer great advice on using polling devices in classes, and for retrieval, I primarily focus on recall type questions. At the beginning of a class, I ask several poll questions to gauge the level of understanding of the material and gain information on what I will spend more attention to in the class discussion. I also have written poll questions during classes when I want to find out if it is a good time to move on from one topic to another.

B. Connections

In a face-to-face format, a simple brain dump from students can reveal the knowledge they are bringing in regarding a concept before you cover it in a class. In the 100% online format, you can use the Chat function in Zoom at the end of a class to ask questions about future material. When doing this, you can ask all students to spend a few minutes writing their answers, but not to press send until you tell them to. Then, at the same time for all students, you instruct them to submit their responses. This allows for individual thought from each student without being influenced by other students' responses. After the class session is over, you can save the Chat transcript and review the answers to gain insight regarding students' background knowledge of a topic and make connections to those when you cover the material in class. As Flower Darby (Darby and Lang, 2019) notes, "connecting course material and their daily experience can also foster increased value, deep processing, and rich understanding." The collection of personal knowledge from students allows an instructor to facilitate the connection of material to the students' prior knowledge.

C. Practice

In a face-to-face class, students can practice working through problems in a group format, and an instructor can walk around the classroom and give instant feedback and provide scaffolding for students to understand the material. Using Zoom, you can assign students to breakout rooms to accomplish the same tasks. As Levy (2020) notes, the breakout rooms tool can replace the think/pair/share activities that many educators use in a face-to-face classroom. After assigning the questions and creating groups, you can give the students a few minutes to work through the problems, then join each group individually to find out where they are struggling or to ask them to share answers they reach. After joining each group, you can call all students back to class and then call on individuals to share their groups' answers. Overall, my courses create opportunities to practice retrieving information (Learning Curve), working through problems (breakout rooms), and quizzes (worth a smaller percentage) before encountering the material in an exam setting.

D. Motivation

Motivation within a face-to-face class is often done through body language and storytelling. As someone speaks, you can easily signal that you are agreeing to a part of an answer and express joy with a response. This is a little more difficult in a Zoom session, but you can focus on your facial expressions and make sure that you are providing language that is validating the correct responses and addressing the incorrect parts without diminishing the desire to learn. Just like in a face-to-face class, you can arrive at a Zoom class session about 5-10 minutes early and talk with students who log in early. That time mimics the time before the physical class, and you can share the same stories or ask the same questions. Motivation can also be contagious in a face-to-face class as students engage with each other and the material. This highlights the importance of using breakout rooms so students can discuss the material with each other and find out how other students are approaching the material.

E. Growth Mindset

The 100% online classroom is excellent at offering opportunities for an instructor to model a growth mindset. I make sure to let my students know that I knew next to nothing about Zoom in February 2020 and am using it in many different ways now. When I am trying something in a class for the first time, I let my students know what I am learning from the experience. Not surprisingly, I have encountered many setbacks when trying something new. When this happens, I explain what I have learned from my failure in the process. As Joshua Elyer (2018) notes, students' fear of failure jeopardizes learning. We need to create many opportunities for our students to fail and learn from that process. From the Learning Curve

activities to non-graded polling questions to non-graded group challenge questions to quizzes before tests, my online courses offer students many opportunities to engage in the material without encountering a large grade penalty when failing.

Last Spring, there was little time to transition from a face-to-face format. Over the summer, we had some additional time to prepare for our Fall courses. I used this time to consider how to transfer the tools from the science of learning to the online format. This involved creating opportunities for students to retrieve information, make connections between previous knowledge and new material, practice applying newly acquired knowledge, motivate students, and model and encourage a growth mindset.

Conclusion

In March 2020, many of us encountered the task of changing our classes from a face-to-face format to 100% online in a matter of days. During this time, a logical approach was to simply make it through the semester doing the least amount of harm. For Fall 2020, we had an opportunity to design courses from the start in the new format. This paper offers a description of this transition from a face-to-face format to a 100% online format focusing on the science of learning literature. For any reader who has more interest in design decisions, I highly recommend reading *Small Teaching Online: Applying Learning Science in Online Classes* (Darby & Lang, 2019), *Teaching Effectively with Zoom: A Practical Guide to Engage your Students and Help Them Learn* (Levy, 2020), *99 Tips for Creating Simple and Sustainable Educational Videos* (Costa & Pacansky-Brock, 2020), and *The Productive Online and Offline Professor: A Practical Guide* (Stachowiak, Linder, & Talbert, 2020).

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