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GREEN REVOLUTION CONVERSION OF OFFLINE EDUCATION TO ONLINE EDUCATION

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Abstract

As the world has advanced towards technology, we live in an era where information can be acquired from any part of the world from any place, any time and from anybody. The newest advancement in technology is the one where education is being transmitted in the form of bits and bytes across the world. A student who can only dream of being a part of a university located in the other part of the world can now stay at home and study the course that the college has to offer. Gone are the days where the student had to travel all the way to the classrooms to gain knowledge. The advent of online classes have provided path for many to have an access to knowledge. The Green Revolution was a period when the productivity of global agriculture increased drastically as a result of new advances. During this 21st century it is emergence of the education scenario to be acquiring this online education by converting the current offline education. As the trend toward online education intensifies, questions remain regarding the overall efficiency of online courses versus their in-class counterparts.

The current paper seeks to estimate the efficiency of students who take online courses relative to the efficiency of students who are enrolled in offline courses. Efficiency outcomes are defined in terms of (1) quantitative scores achieved by the student at the end of the course, (2) the student's viewpoint of how much they learned in the course and (3) the student's level of satisfaction with the course. The authors use Data Envelopment Analysis (DEA) to estimate a model of student efficiency. Demographics, student experience and student preferences are examined as differentiating attributes. The sample is taken from a course offered both online and in a traditional classroom setting, with both formats being taught by the same instructor in a single semester. Implications includes a better understanding of the strengths and weaknesses in efficiency of different course formats.

Keywords: Efficiency Analysis, Online Education, Offline Education, Student Experience, Need of Online Education.

Introduction

Teaching in the 21st century is riddled with technology that brings the ability to offer students anytime, anywhere performance possibilities for course work. But is this flexibility in an online delivery format as efficient as the traditional face-to-face learning experience? As the trend toward online education intensifies, it leaves in its wake a series of questions that remain unanswered regarding the overall efficiency of these online courses versus their in-class (i.e. offline) counterparts.

Research comparing online versus face-to-face learning is mixed, with results ranging from online superiority to no difference to face-to-face superiority. Many results can be traced to sample or method differences. This paper improves on previous efforts by using online and face-to-face samples of the same course, same student population and same instructor and applying a new approach to analysis. A Data Envelopment Analysis (DEA) approach builds a model with effort as the input and efficiency outcomes including student performance, perceived learning and student satisfaction (Banker, Charnes and Cooper, 1984). The efficiency ratio desired in this study is akin to the efficiency ratio achieved using the DEA model in a business setting. Therefore, estimating the efficiency of students who take online courses relative to the efficiency of students who are enrolled in offline courses expands upon the current thinking in the literature.

Review of Literature

Scholars have laid ingots of evidence suggesting there is no difference in online versus offline student performance based on student demographic characteristics (Huh et al., 2010).In evaluating student performance based on student completion rates of materials, Olson (2002) found insufficient evidence to indicate that online versus offline delivery is a factor influencing a student‟s completion of his or her coursework. Others found lower student performance in online classes (e.g., Trawick, Lile and Howsen, 2010), while some even found higher learning in an online format (e.g., Detwiler, 2008).

In a comparison of traditional and hybrid sections of Principles of Marketing, Priluck (2004) found no difference in performance, yet significant difference in student satisfaction. As technology continues to braid its way into all teaching and learning methods, investigations reveal a consistent use of the term “performance.” Performance appears ubiquitous, unless otherwise stated by investigators, as “assessed at the end of the course” by the student‟s “final mark,” otherwise

known as the course grade (Bliuc et.al., 2010; Olson, 2002). Other means of defining student performance include using student test scores or other graded items (e.g. discussion boards, homework) as a variable (McFarland and Hamilton, 2005; Rivera and Rice, 2002).

The term "performance", unless otherwise indicated by the investigator, tends to indicate a grade achieved by the student irrespective of whether student performance is a course grade or an item grade. So far as studies predict student performance, indications are that the format of learning, i.e. offline or online, is not a sufficient treatment to influence significant difference in a performance outcome (McFarland and Hamilton, 2005; Rivera and Rice, 2002; Olson, 2002). In two studies reviewed, student learning was inferred by using the student grades during the end of the course (Biktimirov and Kassen 2008, Brown and Liedholm 2002).

Consistent results in the literature expose the possibility that more than the format of learning is a factor in identifying influencers to student performance. While educators grapple with the transformation of formats and technical solutions for delivering coursework, so too are investigators engaged in a haze of indicators attempting to discover tactual aid for educators to use.

Investigators have explored everything from a student‟s journal of activity (i.e hits, access, attendance) (Biktimirov and Klassen, 2008; Chen and Peng, 2008; Cappeland Hayen, 2004) to a student‟s age, race, GPA, homework, and test scores (Lundgren and Nantz, 2002; ChuenandKan, 2002) to capture signposts on how an educator might enhance student learning in either online or offline forums.

Distinctive in these research efforts are a few investigations that branch out to consider student learning styles, study patterns, and student learning approaches (Bliuc et.al., 2009; Lu, Yu and Liu., 2003). Taking a psychometric approach helps expand issues for future investigators to consider. Despite an increasing amount of research on technology and teaching, questions remain unanswered with regard to the overall efficiency of online courses versus their in-class counterparts. When thinking about performance in terms of the role of the student as a producer, the student becomes a decision making unit (DMU) (Banker et.al., 1984).

Our idea of categorizing students as DMUs yields factors to consider as investigators. One such factor that is commonly used in determining the performance of a DMU is an efficiency rating. This study seeks to estimate the efficiency of students who take online courses relative to the efficiency of students who are enrolled in offline courses.

Data Envelopment Analysis (DEA) is an ex post facto tool that assesses the relative efficiency of the DMU (Banker et.al., 1984). DEA examines the DMU‟s ability to accomplish the desired outcome in production by using an efficiency rating in its predictive calculations (Banker et.al., 1984).

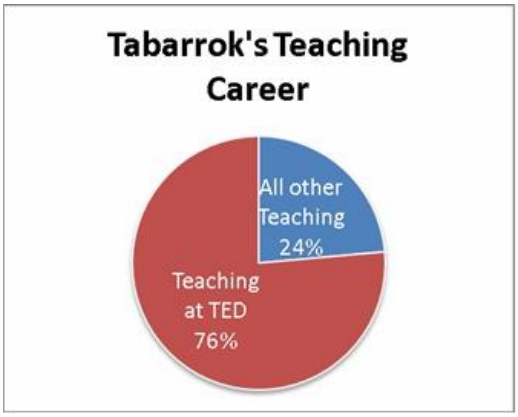
DEA analysis, created by Banker (1980) and Banker et al. (1984), forged a link between the actual productions achieved by the manufacturer as a result of evaluating, post hoc, the DMU inputs for decisions that impact performance efficiencies. Considering that decision makers in DMUs have certain quantifiable inputs to consider, Banker and team proposed a post hoc evaluation tool that yields an „efficiency measurement‟ of management decisions by creating the DEA model (Banker and Morey 1986).

The vital contribution achieved by a DMU using the DEA model means that management can run mathematical scenarios to determine the relative efficiency of management decisions to predict production outcomes. Seeing students as the "management decision makers" of their own academic performance is an unprecedented way of considering how to evaluate student performance.

Need To the Conversion of Offline Education to Online Education

Leverage

The importance of leverage was brought home to me by a personal anecdote. In 2009, I gave a TED talk on the economics of growth. Since then my 15 minute talk has been watched nearly 700,000 times. That is far fewer views than the most-watched TED talk, Ken Robinson's 2006 talk on how schools kill creativity, which has been watched some 26 million times. Nonetheless, the 15 minutes of teaching I did at TED dominates my entire teaching career: 700,000 views at 15 minutes each is equivalent to 175,000 student-hours of teaching, more than I have taught in my entire offline career.[1] Moreover, the ratio is likely to grow because my online views are increasing at a faster rate than my offline students.



Teaching students 30 at a time is expensive and becoming relatively more expensive. Teaching is becoming relatively more expensive for the same reason that butlers have become relatively more expensive–butler productivity increased more slowly than productivity in other fields, so wages for butlers rose even as their output stagnated; as a result, the opportunity cost of butlers increased.

The productivity of teaching, measured in, say, kilobytes transmitted from teacher to student per unit of time, hasn't increased much. As a result, the opportunity cost of teaching has increased, an example of what's known as Baumol's cost disease. Teaching has remained economic only because the value of each kilobyte transmitted has increased due to discoveries in (some) other fields. Online education, however, dramatically increases the productivity of teaching. As my experience with TED indicates, it's now possible for a single professor to teach more students in an afternoon than was previously possible in a lifetime.

The counter-argument is that there is an ineffable quality of the classroom experience that raises its value well above the same material taught online. Even after many years of teaching, however, what exactly this quality might be remains ineffable to me. Actually, that is not quite fair. Bringing the most advanced students in any field up to the cutting edge of knowledge and beyond has always required a kind of apprenticeship rather than a more straightforward communication of data/knowledge.

Fields with greater physicality, not just sports and dance, but also experimental biology, physics, and chemistry will also require more in-classroom teaching with greater attention from a human being. Even recognizing these exceptions, however, still leaves the vast majority of teaching open to massive productivity increases. Until late college, physics is mostly teaching knowledge known since Newton. Most of the mathematics known or needed by most people has not advanced much beyond Euclid and Pythagoras, let alone Euler. No one expects online education to substitute for apprenticing to a master, but much education at the college level is already mass education taught not by a master but by an adjunct.

For the sake of argument, however, let us accept that classroom teaching has some special value. We must still weigh this value against the productivity increases (and thus the cost decreases) potentially available from online education. The majority of my teaching comes from my 15 minute TED talk, but the vast majority of the cost comes from the minority of offline teaching. The 700,000 viewers of my TED talk were charged nothing, but the far smaller group of people who have taken my offline classes were charged, along with the taxpayers, upwards of a million dollars.[2] With

these cost ratios, one imagines that many students would appreciate the option of a lower-cost product even if quality were somewhat lower. Quality, however, need not be lower with online education. Quality can increase by increasing the number of students taught by the best teachers and by substituting substantial capital for labor in teaching.

The best way to increase the quality of teaching is to increase the number of students taught by the best teachers. Online education leverages the power of the best teachers, allowing them to teach many more students. Moreover, online education means that we also see the best at their best. I won't comment on my teaching quality but what I can say without fear of dispute is that the 15 minutes of teaching in my TED talk was among the best 15 minutes of my career. Knowing the potential size of the TED audience, I honed my talk and visuals with months of practice. I'd rather be judged by my best 15 minutes than by my average 15 minutes. My offline students get my average 15 minutes; my online students get my best 15 minutes.

Teaching today is like a stage play. A play can be seen by at most a few hundred people at a single sitting and it takes as much labor to produce the 100th viewing as it does to produce the first. As a result, plays are expensive. Online education makes teaching more like a movie. Movies can be seen by millions and the cost per viewer declines with more viewers. Now consider quality.

The average movie actor is a better actor than the average stage actor. If you were making a movie with a potential audience in the millions wouldn't you hire the best actors? With more viewers it also makes sense to substitute capital for labor, adding special effects, scenery, music and other quality improvements resulting in a movie experience unlike any that can be created on stage. Is there something ineffably great about a live performance? Occasionally, but the greatest stage performances are seen by only a handful of people.

The parallel between movies and plays and online and offline education has further lessons. First, the market for teachers will become more like the market for actors, a winner-take-all market with greater inequality and very big payments at the top.

A principal player on Broadway might earn $62,500 a year, perhaps twice what a minor player might earn.[3] One of the biggest stars in the world, Julia Roberts, made $35,000 a week, or $1.62 million in a 50-week year performing in *Three Days of Rain*. Nevertheless, her stage salary pales in comparison to her typical payment of $10–$20 million per movie for much less work. Bigger markets support larger salaries, so the best teachers will earn much more in an online world.

Second, movies are better in many respects than plays, but no one doubts that a taped play is worse in all respects than a live play. Many of the early online forays into education were simply taped lectures, boring, flat, and worse than the same in-class lecture. To take full advantage of the online format, an online lecture has to be different from an in-class lecture. Different mediums demand different messaging. I turn to some of these differences now.

Time Savings

Tyler Cowen and I have created a new online education platform, MRUniversity.com, short for Marginal Revolution University, after our blog of that name. In putting together our first course, Development Economics, we were surprised to discover that we could teach a full course in less than half the lecture time of an offline course. A large part of the difference is that online lectures need not be repetitive.

Dale Carnegie's advice to "tell the audience what you're going to say, say it; then tell them what you've said" makes sense for a live audience. If 20% of your students aren't following the lecture, it's natural to repeat some of the material so that you keep the whole audience involved and following your flow. But if you repeat whenever 20% of the audience doesn't understand something, that means that 80% of the audience hears something twice that they only needed to hear once, highly inefficient.

Carnegie's advice is dead wrong for an online audience. Different medium, different messaging. In an online lecture it pays to be concise. Online, the student is in control and can choose when and what to repeat. The result is a big time-savings as students proceed as fast as their capabilities can take them, repeating only what they need to further their individual understanding.

We get even more savings by eliminating the fixed time-costs of attending class. Before I even begin my lecture, many of my students will have driven half an hour just to attend the class, followed by another half an hour to get home. And with online lectures there is no looking for parking! Combining these savings with more concise lectures and we get big time savings.

Time Shifting

As with a play, offline teaching requires that every customer consumes at the exact moment that the supplier produces. As with a movie, online education is consumed and produced more flexibly. In the online world, consumers need not each consume at the same time, and suppliers need not produce at the moment of consumption.

It's costly to coordinate consumers and suppliers, and the increase in cost reduces the amount of education consumed. I teach a class at George Mason University, 7:20–10 pm on Tuesday nights. I suspect that this is not the preferred time to learn for *any* of my students, and it's certainly not the preferred time for me to teach; it's merely the best time to coordinate me and as many students as possible.

The inflexibility of offline teaching also reduces the quality of teaching and of learning. Despite caffeination, by 9:30 pm fatigue sets in, and my teaching quality begins to fall. I am not as sharp at 9:30 pm as at 7:30 pm, and neither are my students.

As the quality of both sender and receiver declines, less is communicated. As a result, it makes little sense for me to try to teach complex ideas after 9:30 pm. I try to structure my class to accommodate, but sometimes it's not possible and I end up either teaching less or teaching less well.

Supermarkets are open 24 hours a day, why shouldn't universities be? In fact, Marginal Revolution University is open 24 hours a day, 7 days a week, 365 days a year. Learning on demand. Flexible time scheduling reduces the costs of coordination and also allows students to optimize learning effectiveness by choosing the best time for learning.

Online education can also break the artificial lecture length of 50–90 minutes. Many teaching experts say that adult attention span is 10–15 minutes in a lecture, with many suggesting that attention span has declined in the Internet era.[4] A good professor can refocus the attention of motivated students over longer periods. Nevertheless, it is clear that the standard lecture length has not been determined by optimal learning time but by the high fixed costs of traveling to school.

Lower the fixed costs and lectures will evolve to a more natural level, probably between 5–20 minutes of length—perhaps not coincidentally the natural length of a lecture is probably not that different from the length of a typical popular music track or television segment.

Individualized Teaching and New Technologies

A common objection to online education is that the classroom experience provides greater opportunity for personalized learning. In some cases this is true, but the offline experience is often not a classroom of 4-9 students, but a classroom of over 100. At Virginia Tech, classes of 100-plus students are not uncommon, and one freshman course in geography has some 2,700 students.[5] Virginia Tech is not unusual.

The conventional wisdom is that the classroom allows for more questions. The truth, however, is that the online space is a better place both for asking questions and for interacting with professors and other students. Put aside that students from all over the world can ask questions online. The problem is that a classroom lecture is constrained by the costs of coordination to begin and end at a time fixed in advance. If every student in a class of 50 asked one question per lecture there would be no time for the lecture.

In contrast, questions can be asked at any time in an online lecture, and they do not impede the lecture. Moreover, in the online world there are more resources to answer questions. Answers to last year's questions, for example, can be used to answer this year's questions.

More importantly, the online world makes it easier for peer-learning, for students to answer their own questions. At MR University we have provided tools such as voting on questions and answers that we hope will allow for more peer-learning and peer-teaching. Hence our motto: Learn, Teach and Share.

Questions are also more powerful in the online world. Consider how much difference is made by the simple possibility of review. Review means that the teacher is held to a higher standard. If I make an error in my offline class, chances are no one will catch it. If I make an error in an online class, a student will invariably catch it. (Knowing this I am more careful in my online class.).

Technology is rapidly changing how much interaction can occur online. The future is lectures plus intelligent, on the fly assessment. The GRE, for example, is a computer-adaptive test—when you answer questions correctly you get a harder question; when you answer incorrectly you get an easier question. The adaptive nature of the test makes it possible to zero in more quickly on true ability.

The future of online education is adaptive assessment, not for testing, but for learning. Incorrect answers are not random but betray specific assumptions and patterns of thought. Analysis of answers, therefore, can be used to guide students to exactly that lecture that needs to be reviewed and understood to achieve mastery of the material. Computer-adaptive testing will thus become computer-adaptive learning.

Computer-adaptive learning will be as if every student has their own professor on demand—much more personalized than one professor teaching 500 students or even 50 students.

In his novel *Diamond Age*, science fiction author Neal Stephenson describes a *Young Lady's Illustrated Primer*, an interactive book that can answer a learner's questions with specific information and also teach young children with

allegories tuned to the child's environment and experience. In short, something like an iPad combining Siri, Watson, and the gaming technology behind an online world like Skyrim. Surprisingly, the computer will make learning less standardized and robotic.

In *Diamond Age*, the very first *Illustrated Primer* is created by a billionaire for use by his own child, but within a decade only slightly less functional devices are made available to millions. Online education has the potential to break the cost disease by substituting capital for labor and hitching productivity improvements in education to productivity improvements in software, artificial intelligence, and computing.

Productivity in education has lagged productivity in other sectors of the economy because teaching is so labor intensive. Where exactly in the typical classroom is there room for investment, let alone productivity improvement? More chalk? Prior to online education, the bottleneck though which productivity improvements had to pass was the teacher, and we know that improving teacher productivity is very difficult, which is why teaching methods haven't changed in millennia. Online education vastly increases the potential for productivity increases because it greatly increases the size of the potential market.

Bigger markets increase the incentive to research and develop new products (coincidentally the very topic of my TED talk.) A tool used to improve online education–an interface, an algorithm, a new teaching method–can be applied vary widely, potentially world-wide, thus greatly increasing the incentive to invest in the education sector, perhaps the most important sector of the 21st century economy.

Educational productivity will also increase with online education because online education is inherently data-rich. Every video watched, every link clicked, every question answered or not answered, all can easily be collected and analyzed. Randomized controlled trials, which are very expensive in the offline world, become very cheap in the online world. Consider two methods of teaching a concept.

Which works best? In the offline world, a randomized controlled trial might involve 50 students. In the online world, we can randomly assign one of two videos to thousands of students and then monitor their performance days or weeks later on exams or other material. Online education will allow us to learn about what works much more quickly than in the past.

Online education will also dramatically shorten the time from learning what works to implementing what works. Once again, scale and leverage are key. In the online world, the best teachers will teach more students, but that leverage also

means that better teaching methods can diffuse through fewer teachers to more students much more rapidly. In the limit, educational improvements will occur with a download in the same way that my DVR player periodically updates its operating software.

The College Experience

The college experience is about much more than learning. Online education will not replace the two Olympic-sized swimming pools at my university, the modern exercise facilities, the coffee shop, or the restaurants. At many institutions, online education will not replace but instead will supplement and complement the traditional college experience.

"Flipping the classroom" viewing online lectures at home and doing "homework" in-class is one approach. More generally, many institutions will be able to raise the quality and breadth of the classes that they offer. Not every university can afford world-class lecturers in development economics, the history of Croatia, or pop art, but more universities will be able to offer such courses by supplementing their own lecturers with online offerings.

The university will continue to be a place for young people to socialize and mate, but when the shroud of education is lifted, the socialization and education functions will become more distinct. As socialization and education are unbundled, parents and taxpayers may decide that they would rather not pay for five years of socialization when cheaper means of education are available.

It's important to understand that already today the "college experience" is experienced by only a minority of students. Say "college student" and the image may be of a young person just out of high school living in a dorm pursuing a four year degree with few financial constraints.

The reality is that more than a third of college students are over the age of 25, nearly half are enrolled part-time, and most are working. About one quarter of college students have children of their own! The traditional college experience does not meet the needs of most of today's students.[6]

Online Education Has Already Met the Market Test

Online education hit the radar of the educational elite only recently with the unexpected success of Stanford's free online course on artificial intelligence. Taught by Peter Norvig and Sebastian Thrun in 2011, this course enrolled more students than the entire Stanford student body.

Educational startups like Coursera, Udacity and, of course, MR University promoted the idea of MOOCs, massive online open courses. The elites, however, have been behind the curve. In 2011, even before the rise of MOOCs, there were 2.75 million online students, 12% of the headcount at degree-granting schools. [7]

Private, for-profit universities such as the University of Phoenix and Ashford University were the pioneers of online education. The for-profits offered courses that appealed to women, particularly those with children, to ethnic minorities and to adults 25–44 years old who valued all of the flexibility and time-savings that online education offered. Online education has also been especially successful in the graduate market, particularly for the Master's degree, which is shorter and pursued by adults less interested in the socializing and mating functions of the traditional college—indeed, today the Master's degree is already more than 30% online.[8]

By selling (and marketing) to an audience that traditional universities had mostly ignored, the for-profits increased market share tremendously in the 2000s. Questions about quality and large subsidies from taxpayer funds have plagued the for-profits, but we should not mistake the messenger for the message. Online education has already met the market test.

Online Education and the Developing World

The shift to online education is happening at the same time as the developing world is increasing education at a dramatic rate. Over the next 15 years or so India plans to increase the number of students attending university from 12 million to over 30 million; a goal that will require at least 1,000 new universities. China has already increased the number of entering university students from 1 million in 1998 to over 6 million today. Now consider, will the developing world adopt the Oxford model of 1096 or the newly emerging online model? It's a good bet that for reasons of scale, speed, and quality the developing world will adopt the online model.

The Great Unbundling

Traditional universities combine course development, delivery, assessment, and credentialing. Online education makes it clear that these categories can be unbundled. Most of the MOOCs are currently offered for free with no credential, but institutions such as Western Governor's University and Colorado University are beginning to credential courses produced from outside of their institutions.

It's possible to imagine an education system in which degrees are assembled from many sources and many institutions offer credentials based on various types of assessment. Already many universities now offer credit for courses taken at other universities, and in some systems, such as Australia's, simultaneous cross-institutional enrollment is standard.

Unbundling development from the other functions means greater economies of scale. Unbundling assessment offers the possibility of proof of knowledge without taking a class.

We already have some experience with unbundling credentialing in the market for lawyers where law schools train students who must then pass the bar.

Conclusions

Technology is disrupting the market for education just as it has disrupted the market for news. We do not yet know how the industry will shake out, but a few points can be made with confidence. Online education offers tremendous savings both in terms of money and of time.

Online education will also increase the quality of education for many but not all courses, especially as investment in complementary technologies increases. The for-profit universities have already moved heavily into online education and the non-profits are poised to follow.

What are less clear is who will be delivering the online content of the future, how knowledge will be assessed, and how learning will be credentialed.

We should also not count the old model out. Having never observed an alternative, we may not yet fully appreciate the old model's strengths. The online conversion model weathered previous technological storms, not the least of which was the printed book. Nevertheless, the disruption potential is peaking now.

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