

Covid-19 Pandemic and Its Impact on College Teaching: The Unexpected Benefits and their Consequences

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Abstract: *The authors have been teaching mathematics and economics for more than 15 years at two nonresidential colleges in New York City: Metropolitan College of New York and Bronx Community College, which is part of the City University of New York (CUNY).*

Until the first week of March 2020, the authors were teaching all their classes in-person. With the outbreak of Covid-19 epidemic, both colleges were immediately closed. The Spring 2020 semester was interrupted, and all professors were given less than 10 days to prepare their respective classes through distant education using the Zoom platform, or equivalent, for instruction.

While the transition was abrupt, the authors soon discovered that conducting some mathematics and business classes remotely yielded unexpected advantages to many students, professors and colleges alike. This article offers specific examples the authors used in teaching remotely on Zoom and discusses the improved pedagogy that can be applied only in distance learning.

With recruitment and retention of undergraduate students being a growing concern for U.S. colleges, economic survival will depend on an institution's ability to adapt technology and flexible tuition structure in new post-pandemic future.

COVID19 EPIDEMICS: SOCIO-ECONOMIC AND EDUCATIONAL IMPACT

By the end of September 2020, more than 7,500,000 U.S. inhabitants were infected with the Covid-19 virus and about 210,000 of those infected died. The number of deaths is higher than the total number of deaths in World War I, Vietnam War and Korean War (134,512 deaths) and is equal to 2/3 of the number of deaths during World War II (291,557 deaths)¹. As a consequence, the number

¹ Data Source: Congressional Research Service. (2020, July 29). *American War and Military Operations Casualties: Lists and Statistics*

of infected people who have remained with chronic medical illnesses after recovery is probably comparable with the number of impaired veterans after World War II.

As a result of its extraordinary magnitude – comparable only with the magnitude of the Influenza (Spanish Flu) Pandemic of 1918 that caused an estimated number of 675,000 deaths in the United States²– the Covid-19 pandemic has had and will have a very important economic, social and political impact. Revolutionary changes are taking place in the business models of some of the most powerful multinational corporations, in running political campaigns, and in all types of social activities.

Google’s employees will work from home at least until June 2021 (Fung, 2020), the Democratic and Republican national conventions during the U.S. presidential campaign were held online, and the leaders and parliament members of most countries are continuously wearing masks.

The retail and restaurant industries, the travel and leisure industry and the entertainment industry have been brutally affected. The number of scheduled passengers boarded by the global airline industry decreased from 4723 million before the pandemic to 2246 million by June 2020 (Mazareanu, 2020), and the volatility of the price of crude oil was extraordinary. It went from about 54 dollars on February 20 to 18 dollars on April 24 and to about 40 dollars currently.

These powerful and dramatic processes have been embodied in the temporary or final closure of tens of thousands of small and medium businesses. Consequently, the unemployment rate increased vertiginously from 4.4% in March to 14.7% in April, and although it has slowly decreased since May, it continues to be relatively high at about 7.9%.

In general terms the service sector of the economy has been the most vulnerable. It has been affected the most because it is more labor intensive and less capital intensive than the manufacturing sector. And this fact should be an alarm signal for higher education, because higher education is a service and is labor intensive. It is true that it is a service that uses highly educated and skilled labor, but this does not change its inclusion in the service sector or its characterization as labor intensive. A college or university is essentially defined by its professors and students, not by its buildings.

The demand for higher education is relatively elastic, and it depends as any demand of a service or commodity on quality, price and buyers’ income. Therefore, under the economic and social circumstances caused by the pandemic, the system of higher education is under high pressure.

² Data Source: CDC Centers for Disease Control and Prevention. *History of the 1918 Flu Pandemic*.
<https://www.cdc.gov/flu/pandemic-resources/1918-commemoration/1918-pandemic-history.htm>

Most current and potential students regard the strictly online, asynchronous, higher education (using only Moodle or a similar software) as being inferior to the traditional face-to-face, in classroom education. Subsequently, they are reluctant to pay the same tuition for a service they perceive as being relatively inferior, and expect tuition reduction in order to start or continue their higher education.

At the same time this expectative state is reinforced by the decrease in their personal income and/or in the income of their parents caused by the increase of unemployment. Finally, as a result of the conjuncture of these two factors – perception of cost quality as unfair and income reduction – naturally enrollment has the tendency to decrease.

In this context, adapting the models of higher education used by colleges and universities to the new economic and social conditions imposed by the pandemic and post-pandemic circumstances is more than a problem of efficiency improvement. It is a problem of survival for many colleges that requires the imagining of new models of higher education. It is especially serious for the small and medium colleges whose existence is strictly dependent on tuition.

TEACHING MATHEMATICS IN THE PRE-PANDEMIC WORLD

Before Covid-19 struck, the prevailing assumption was that in-person teaching is a must for good and effective mathematics pedagogy. Yet some colleges have been offering online teaching long before March 2020: correspondence classes have existed for more than a hundred years. With the advent of online technology, however, many colleges started offering online, asynchronous classes for some of their courses.

The financial benefits to a college are many: scheduling flexibility and lower overhead and maintenance costs are just two. With online teaching, colleges can consolidate several sessions, thereby reducing their reliance on contingent instructional staff.

In commuter colleges, some students have found that an online asynchronous class offers the advantage of flexible scheduling. A working student with children at home could, for example, wake up at 5 a.m. and study for a class before starting work. Other students might prefer to be at home early in the evening with their family instead of returning at 10 p.m. after attending a class that finished at 9 p.m. As great as that might sound in terms of schedule flexibility, reduced operational costs to the college and reduced transportation costs to the students, asynchronous online teaching is not the ideal way to teach college math classes.

In urban areas, many undergraduate students are unprepared for college work. Some lack basic study skills. They come to class expecting the professor to teach them topics that should have been mastered in their earlier education. For many urban students, these are the same basic mathematic

topics to which they were repeatedly exposed in high school or middle school but that they never understood sufficiently in order to do college work. Without a professor to adapt material to the students' level of understanding, these students are totally lost.

It is not the purpose of this article to elaborate on the pedagogical tools available in an in-person class or to discuss the pedagogical methods the authors used in basic classes working with urban students. Over the years we have worked in mathematics with hundreds of students in both basic math classes and regular classes at the undergraduate, as well as graduate level. But invariably all our classes were in person, face-to-face.

We believed that urban students, as well as their professors, expected mathematics teaching to be in person, in a face-to-face class. From the students' perspective it might have been acceptable for some of the classes to be conducted asynchronously, online, but mathematics? No way! The students were unaccustomed to working independently without a professor in the classroom. In addition, how can a student study with a couple of friends when everyone is locked in their respective apartments?

And how about using the library? For many students, the library was an oasis of calm that offered a wealth of resources, such as technology, books, proper lighting, and a quiet atmosphere away from home where students could focus on their studies. When the college closed, the library closed as well!

When the coronavirus struck with intensity in New York City, the old system of pedagogy was brought to its knees. With the college doors closed, with students and professors locked in their respective homes, we found ourselves in the middle of Spring 2020 semester with students and professors who could not go to college but expected to finish the semester and continue their academic studies, pandemic or no pandemic.

THE MOST CHALLENGING WEEK EVER

Starting on March 10, in one school after another in New York City students tested positive for the coronavirus. First the private schools closed, then the public schools.³ On March 16, 2020 the entire public school system in New York City, comprising more than 1.1 million students attending more than 1,700 schools, was shut down temporarily. What was supposed to be a temporary closing for the public schools in New York City ended up being a complete closing, until the start

³ Shapiro, E. (2020, March 15). New York City Public Schools to Close to Slow Spread of Coronavirus, *The New York Times*

of the new school year in September. Following the school closings on March 10, remote or online instruction was to start on March 19.

Some college closings preceded the closing of the public schools by several days. New York University, Fordham University and Pace University announced the start of online remote teaching on March 1. SUNY and CUNY schools also cancelled all in-person classes on March 11. By March 12, both MCNY and Bronx Community College were closed, and the most challenging week of our pedagogical life began. We were given no more than 7 days to convert our pedagogy to remote, online.

During that week college professors started attending webinars and online training of how to use technology in teaching. Colleges offered training in Moodle or Blackboard Collaborate, to be used for asynchronous teaching, as well as training in Zoom or Blackboard Collaborate Ultra for synchronous teaching.

In addition to the ability to teach asynchronously, Moodle and Blackboard Collaborate provide the ability to post homework, upload lessons and other files, provide links to different websites, send and receive emails, keep attendance, etc. In the public school system Google Classroom was extensively used.

TECHNOLOGY TO THE RESCUE: TEACHING MODALITIES

Because institutions, articles and commentators have used different words and associated diverse concepts with online teaching, we have to briefly explain how we use these terms in this paper:

From a spatial perspective:

- Classes are considered *in-person* when students and professors are together in the same room.
- Instruction that does not take place in person is called *distant* or *remote*.
- When one part of the instruction is in person and the other part is done remotely, the class is called *hybrid*.

From a timing perspective:

- In-person classes are always *synchronous*.
- Distant/remote classes can be either synchronous (by using technology such as Zoom, Blackboard Collaborate Ultra, Google Classroom) or *asynchronous*, for example, when the class is taught with Moodle only.

Asynchronous teaching/learning is accomplished through the internet using Moodle, Blackboard Collaborate (not Ultra) software and many other platforms. Even traditional correspondence schools should be considered distance/remote, asynchronous teaching.

Courses like the ones provided by edX or Coursera, which are conducted through the internet, could be synchronous (even though they are distant/remote learning), asynchronous, or hybrid.

From the perspective of the use of technology, the terminology can get confusing, depending on the context. We are using the following definitions:

- *Hybrid* is as defined above, when instruction is partly in person and partly distant/remote.
- *Online*, or going online, usually means connecting to the internet. All classes conducted through Zoom, Moodle, Skype or Blackboard are online classes since internet access is required. It is preferable not to use that terminology, which can be confusing. In Zoom classes, for example, students must attend the class at a given time (*synchronous* teaching). This is in contrast to Moodle instruction, where students can log in whenever they want (*asynchronous* teaching). In both cases, these classes are *online*.
- *Hybrid* (capital -H) can be tricky. In many colleges, the term describes courses that are taught partially in-person and partially through distant learning.
- *Face-to-face* are classes offered in person on campus. Classes can also be face to face when offered through Zoom, Blackboard Collaborative Ultra, or Google Classroom as long as all students keep their computer, phone or camera on for the duration of the class.

Unlike Moodle, Zoom⁴ hadn't been used in education for a very long time. Zoom was designed initially as a business teleconference tool, where a host could convene a meeting with up to 300 attendees. On their individual screen the participants have control of their microphone and camera (how a person is seen or heard by the others) as well as the way that participant sees the others (as a group or as an individual). In addition, participants can talk to each other privately or as a group using the chat mode.

The host controls who, and when, people can attend the meeting and controls the microphones and the camera of each person or the entire group. The host can connect to websites or spreadsheets, share the screen or allow participants to share theirs. The host can present slides or write on the whiteboard for everyone to see, record the entire session or parts of it, break the group into subgroups or even conduct polling among the participants. The host can even designate another participant to be the host.

Naturally, in the business world, Zoom was a godsend. The amazing thing, though, was how easy it was to adapt Zoom to education. The professor is the host; the participants are the students. The professor can share all teaching materials with the entire class or a subgroup. Instead of writing and then erasing the board to make room for new information, the professor writes or types on the

⁴ Zoom is provided by Zoom Video Communications, Inc. For use of Zoom in education, the company's link is <https://zoom.us/education>

Zoom whiteboard. But instead of having only one board, the professor has a multiple of them and can also easily return to a previous board when needed. With a bit of practice, most people can master Zoom in a few hours. Now you have the perfect replacement for in-person classes.

LIMITATIONS AND BENEFITS OF THE ONLINE TEACHING METHODS

After we have differentiated the meanings of terms, we have to describe the limitations and benefits of the methods of teaching online that have been employed.

The most usual and most frequently used method has consisted in using Moodle or similar software for two-way communication between professor and student. The advantage of this method over the old correspondence college was the speed provided by the internet. The disadvantage was the same as that of the correspondence college versus in-person college, the lack of interpersonal connection and socialization.

A second method of teaching has been the use of hybrid courses associating in-classroom instruction with online activities using Moodle or equivalent software and internet resources. For example, a three-credit course would be offered as a weekly two-credit in-person course and one credit online course, or as a course in which an in-person session will alternate with an online session. This method of teaching eliminates the deficiency of the previously presented one but cannot be used or can be only partially used during a pandemic.

The third method, which consists in using Zoom with Moodle or equivalent software, implies as we have specified before, two types of courses: asynchronous and synchronous. Its main advantage is that it allows face-to-face contact between professor and students and *face-to-face student socialization* without in-person contact. That is a huge advantage during a pandemic.

CLASSROOM TEACHING IN A VIRUAL WORLD TECHNOLOGY

Starting with the third week of March, we taught a total of nine online courses. We taught seven additional online courses during the summer semester. Ten were graduate-level courses in business and education; the other six were undergraduate courses in mathematics. Approximately 250 students were enrolled in all these courses. There were some initial difficulties, such as a few students not having laptops or tablets, but these problems were quickly resolved. The colleges distributed laptops or tablets to all the students. The students also realized they could attend classes even when they were not at home simply by using their smart phone.

All classes were taught remotely, with both professors and students communicating online through Zoom platform. We found the Zoom platform to be the easiest and more adaptable to our needs.

A Zoom subscription allows up to 300 hundred people to communicate simultaneously. There is no time limit for each session. We were able to easily handle classes that last two hours or more.

For years we got used to the idea, we were convinced, that to teach mathematics to a classroom, you have to do it in person with a whiteboard and markers. Dispensing of the board when teaching mathematics was anathema to most mathematics professors. One of the authors was thinking of buying an easel and markers to direct the camera toward the easel. Maybe two cameras would be required, maybe two computers?

His initial thinking was to emulate the classroom in a virtual world. It was a truly quantum leap in our pedagogical thinking to abandon the physical whiteboard and teach the entire lesson from a laptop. We quickly entered a new era, into a revolutionary era of pedagogy, an era that we call *the Zoom Revolution*.

What we experienced was a true technological revolution in college education! The host, in our case the professor, controls who can attend the session, whether students can join the session before the class starts or whether they have to wait in a “waiting room.” The host decides whether to mute all or some students before class starts or at any time during the class. Attendees have control over their camera and their mute button.

Students can send messages to the professor, the entire class or each other. They can ask the professor to repeat an explanation or to slow it down. The host can present slides or write on the whiteboard for everyone to see, record the entire session or parts of it, break the group into subgroups or even conduct polling among the participants. Likewise, the host can even designate another participant to be the host.

In a similar vein, the professor can make another student a host, with all the privileges that position confers. The professor can share the computer screen with the entire class and allow the sharing of screens among individual students. The professor can also record the class session partially, or in its entirety, for distribution to the attendees or to students who missed the session. The recording file could be stored on the computer or in the cloud.

Zoom offers many additional features of the system such as ability to conduct polling or to separate the class into several groups. The professor, as well as the students, has access to a white board that can be shared with the rest of the class. The professor or a student can even type on the whiteboard, display an entire PowerPoint presentation and provide links to the internet.

With a bit of practice, most people can master Zoom in a few hours. Now you have the perfect replacement for in-person classes.

In this context, to get the most out of a Zoom session with our students, we recommend the following rules:

- Classes should be held at fixed times, just like in-person classes.
- Attendance should be mandatory for all classes and for the entire session.
- Students should have the microphone off unless they are invited to speak.
- Cameras should be on for the entire session.
- Students should use their complete roster name.
- Attendance should be taken 10 minutes after class starts and 10 minutes before class ends.
- A four- or five-minute break should follow any lecture longer than 25 minutes. Students complained that they lose concentration during long lectures/sessions.
- To increase effectiveness, each session should include interactivity, group work, guided discovery, and other group processes.
- All sessions should be recorded. This will help students who have poor internet access or students who miss a Zoom class.

By following these simple rules, a Zoom session is as or more effective than an in-person class.

APPLYING TECHNOLOGY TO OTHER LEARNING ACTIVITIES

Naturally, in addition to the scheduled class time, learning happens outside the classroom during the students' spare time. In addition, in a college course there is a lot of communication that goes on outside the classroom between the professor and students (in both directions) and among the students themselves. This applies to homework and tests that have to be submitted on time, grading of assignments, discussion boards, group or individual e-mails.

We have used two platforms to achieve these objectives: in one college the Moodle platform, the Blackboard platform in the other college. With a little learning on behalf of the professor and the students, both platforms did the job very well.

By combining a synchronous technology platform (in our case Zoom) with an asynchronous technology (Blackboard or Moodle), we were able to teach in a virtual classroom and do all the pedagogical and administrative tasks. The students were able to complete the spring semester and to start and complete the summer semester as well.

As far as which technology is preferable to use, this article is not the place to recommend one technology over another. Suffice it to say that it was possible in a very short period of time to switch from in-person teaching to remote teaching and to complete two semesters of classes with a large number of students.

TEACHING MATHEMATICS AND BUSINESS IN A VIRTUAL WORLD

The specific courses that we taught (some of them more than once) since the pandemic started have been the following:

In MCNY School of Education:

- Teaching Mathematics in Grades 1-3 with technology. This is a master-level course.
- Teaching Mathematics in Grades 4-6 with technology. This is master-level course.

In MCNY School of Human Services:

- Basic Mathematics. This is an undergraduate, noncredit course.
- Mathematics for Finances. This is an undergraduate course.

In MCNY School for Business:

- Managerial Economics. This is a master-level course.
- Managerial Finance. This is a master-level course.
- Global Busines and International Practicum. This is a master-level course.

In Bronx Community College:

- Basic Mathematics (mathematics for grades 1-6). This is a noncredit course.
- Precalculus. This is an undergraduate course.

All the above classes were taught with Zoom for the virtual face-to-face sessions. All courses were taught on the same schedule as pre-pandemic courses used to be taught. We used both Moodle and Blackboard for the asynchronous tasks: posting assignments, students returning assignments, course announcements, discussion boards, posting reading materials and links to different websites.

Equipped with our students' college email addresses, we were able to immediately invite all our students to the Zoom sessions, which we scheduled at exactly the same time as the regular classroom sessions. We used Zoom for the virtual face-to-face teaching, interaction with the students and students themselves during classes (visual, verbal, chat, and symbols) and for splitting the class into working groups.

Our students did not have to wait in a waiting room for us to open the sessions. Neither did they have to quit at the end of the class. That way Zoom bridged the geographical distance. Students who never met in person became friends and study buddies over the internet. We encouraged the students to get their own Zoom platform (free for each 40-minute session for a small group) and to use it outside the classroom time with their study groups.

The students even established times of the week at which the small group regularly met to study together. Students who before would have had at best a few minutes to talk to each other at 9 p.m. after an in-person class, were now spending time exchanging pleasantries and getting to know about each other's family, children and even pets. Zoom became thus not only an instrument in teaching but also of socialization. From a mathematics or business perspective, the learning in small groups enhanced the efficiency of learning. We discovered that at times learning with a couple of students is much more efficient than listening to a professor's lecture.

SPECIFIC EXAMPLES ON TEACHING MATHEMATICS SYNCHRONOUSLY

As mentioned already, all our classes were taught on Zoom. To write the equations or any notes instead of a physical whiteboard, the professor used the Zoom whiteboard or at times another electronic whiteboard.

Writing equations by hand on the whiteboard was accomplished through a Wacom tablet⁵ connected to the laptop through Bluetooth. The Wacom tablet costs less than \$100, but requires some practice, similar to typing without seeing the keyboard while looking at the screen. In the endnotes we provide a link to a video demonstrating how to use the Wacom tablet for teaching mathematics online.

Other technological solutions exist such as using a touch-screen computer with a stylus. These computers come equipped with software allowing writing on the Zoom or other whiteboard. To display the graphs we used screen-sharing and we accessed a graphic calculator online. We used Desmos graphic calculator⁶, but other software programs could do the job as well.

For a professor to write on a physical board with colored chalk and colored markers, erasing the board each time the board fills up, it is a real discovery to use a virtual board containing literally an infinite number of pages. The professor can work on page number 5, for example, and return to page number 1 or 2 to answer a student's question. Naturally, in the physical world the previous pages disappeared when the board was erased.

Since our classes are composed of students from different disciplines (business, education, human services, nursing, engineering), when working on the examples we discussed their applications in the different disciplines. For example:

In business:

⁵ The Wacom Tablet is manufactured by Wacom Co., Ltd. For how the tablet can be used in an interactive classroom, the link is <https://www.wacom.com/en-us/discover/educate/interactive-classroom>

⁶ Desmos Graphic Calculator is used in precalculus and calculus courses. The calculator is provided by Desmos, Inc. The link is <https://www.desmos.com/calculator>

- the intersection between supply and demand curves
- profit optimization under different constraints: the slope of the curves, the meaning of the asymptotes

In human services:

- number of cases of Coronavirus; maxima and minima; “bending the curve”
- future projections under different scenarios
- use of exponential functions to predict population growth

In engineering:

- combination of forces, each one represented by a different function
- composition of functions in microchip construction

The examples below show how the actual mathematics appeared on the Zoom screen of our students. The students used screen shots at different stages of solving a problem. By using Desmos graphing in conjunction with the whiteboard (on which we wrote or typed), we appealed to the students’ mathematical thinking. We did not provide them the solutions but helped the students to explore each step and to find the solutions themselves.

Example 1: Transformation of functions

We aimed for the students to understand the relationship between algebra and analytic geometry. We stressed that the same transformation concepts apply to *any function*, not necessarily polynomial, as will be seen in example #2 below.

We started by using the basic quadratic function, $y_0 = x^2$ (Figure 1). Students were asked how the function should be modified algebraically to obtain the following graph movements:

- y_1 , by vertical translation, 3 units up (Figure 2A)
- y_2 , by vertical translation, 2 units down (Figure 2B)
- y_3 , by horizontal translation, 2 units to the left (Figure 2C)
- y_4 , by horizontal translation, 3 units to the right (Figure 2D)

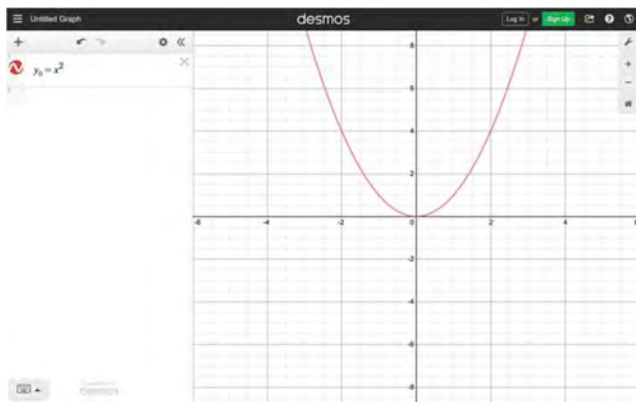


Figure 1: Graph of $y_0 = x^2$ in Desmos online graphing calculator.

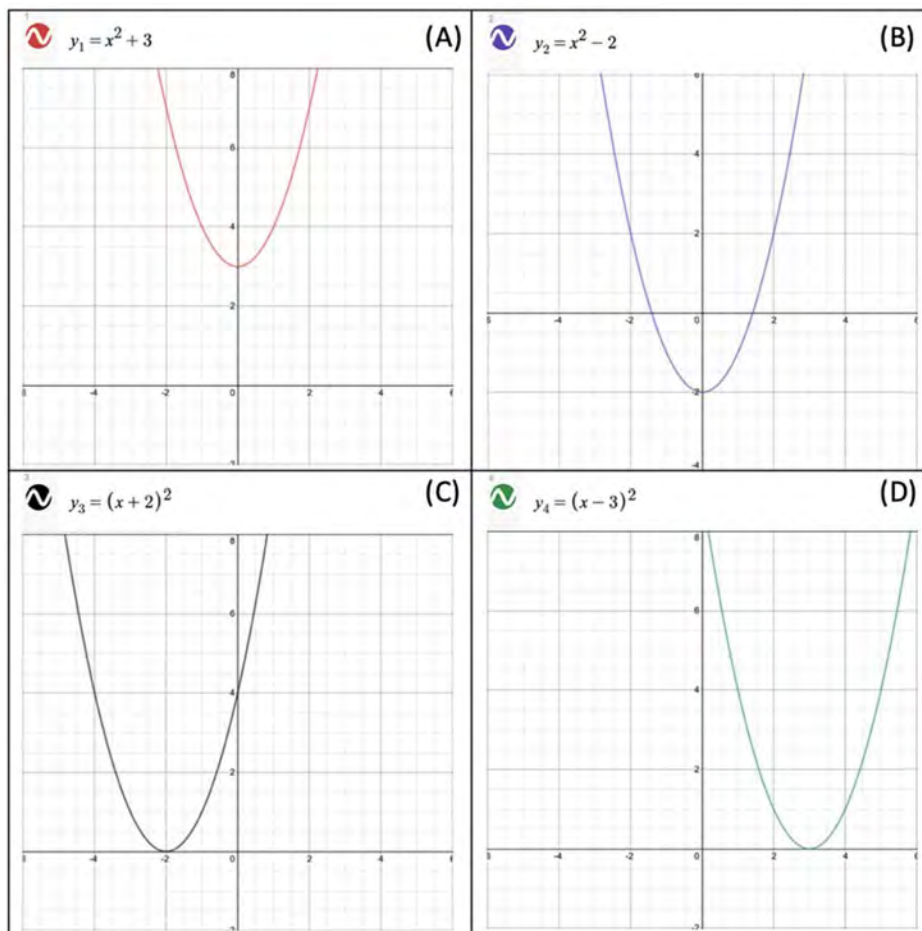


Figure 2: Vertical and horizontal translations of the function $y_0 = x^2$.

Reflect the function y_4 from Figure 2D over the x-axis to obtain y_5 (Figure 3).

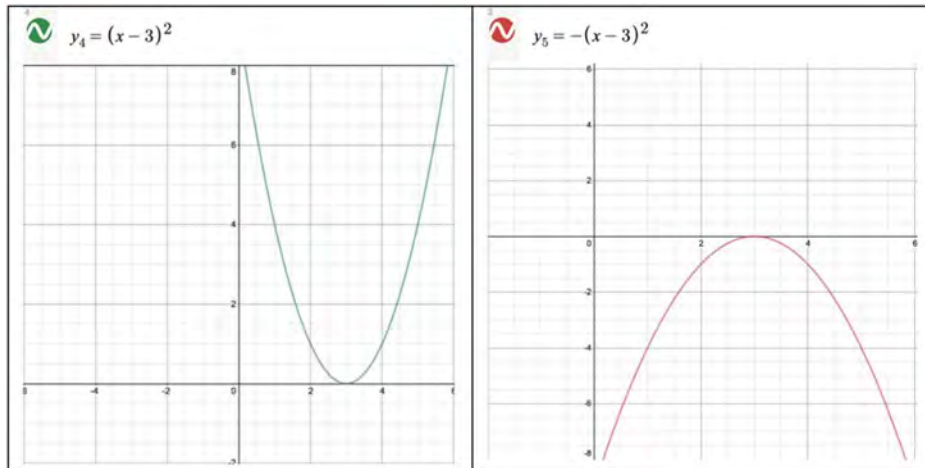


Figure 3: Reflection of $y_4 = (x - 3)^2$ over the x-axis.

Stretch the function y_4 from Figure 2D vertically by a factor of 2 (Figure 4A) and horizontally by a factor of 0.5 (Figure 4B). Find the zeros of each function.

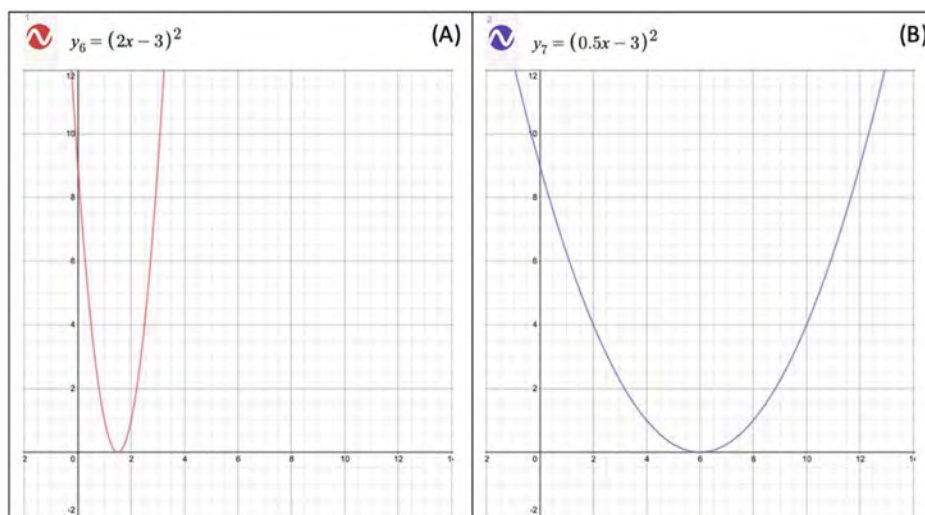


Figure 4: Stretching of $y_4 = (x - 3)^2$ by a factor of 2 (Figure 4A) and 0.5 (Figure 4B).

Example 2: Transformation of functions – A non-polynomial function

Given the function $F_1 = \frac{1}{x^2}$ (Figure 5), move the graph first 2 units to the right (Figure 6A) and then 5 units up (Figure 6B).

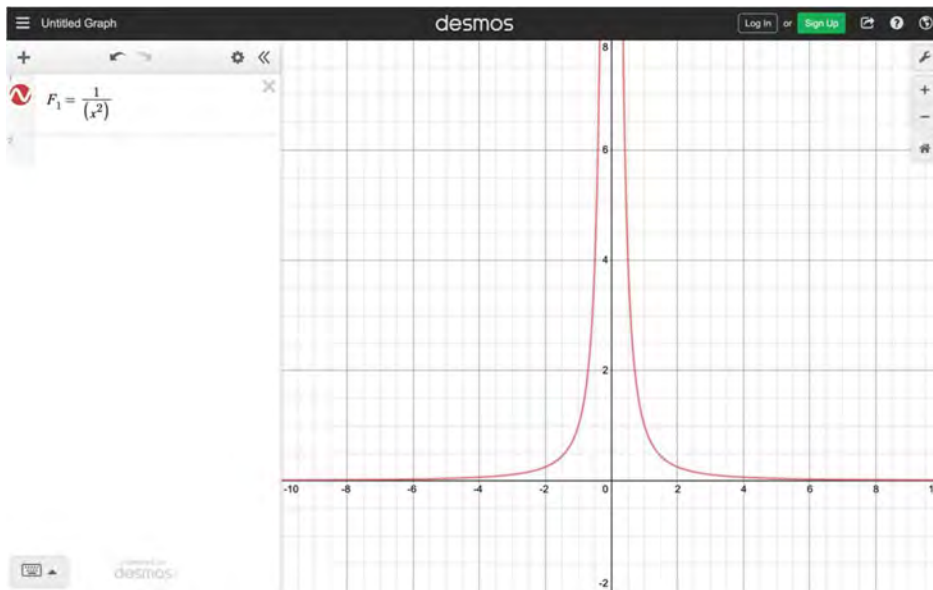


Figure 5: Graph of $F_1 = \frac{1}{x^2}$ in Desmos online graphing calculator.

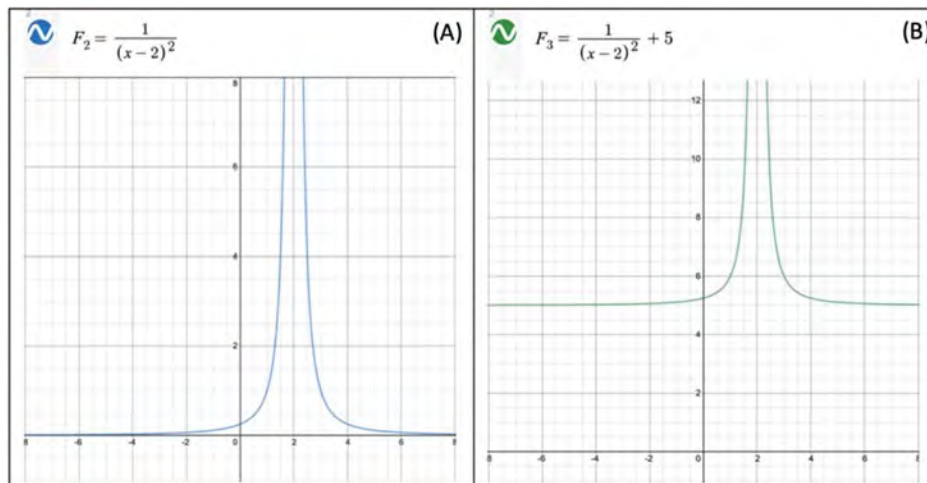


Figure 6: Graph of $F_1 = \frac{1}{x^2}$ moved 2 units to the right (Figure 6A) and 5 units up (Figure 6B).

Example 3: Rational functions

Given the rational function $y = \frac{2x+1}{3(x-2)(x+1)}$, (Figure 7), examine the graph for the vertical and horizontal asymptotes.

- Find the vertical asymptotes by equating the denominator to zero.
- Why is the x-axis the horizontal asymptote?
- In a given interval, could a function have more than one horizontal asymptote?



Figure 7: Graph of $y = \frac{2x+1}{3(x-2)(x+1)}$ in Desmos online graphing calculator with vertical asymptotes $x = -2$ and $x = 2$ indicated.

Example 4: Identification of a demand curve

This is an example of demand curve identification presented to students taking the Managerial Economics course to illustrate the theoretical concepts of demand function and demand curve.

The manager of a gas station decided to identify his customers' demand curve for gasoline in order to improve the profitability of his gas station. Subsequently, he collected data during a three-month interval of time and on this basis created the following table indicating the relationship between the price of a gallon of gasoline and the average number of gallons sold per day. Let's determine

the demand curve using EXCEL and observe its shape depending on showing the price on the horizontal axis or of the vertical axis, considering that in economics the price is shown on the vertical axis although it is the independent variables.

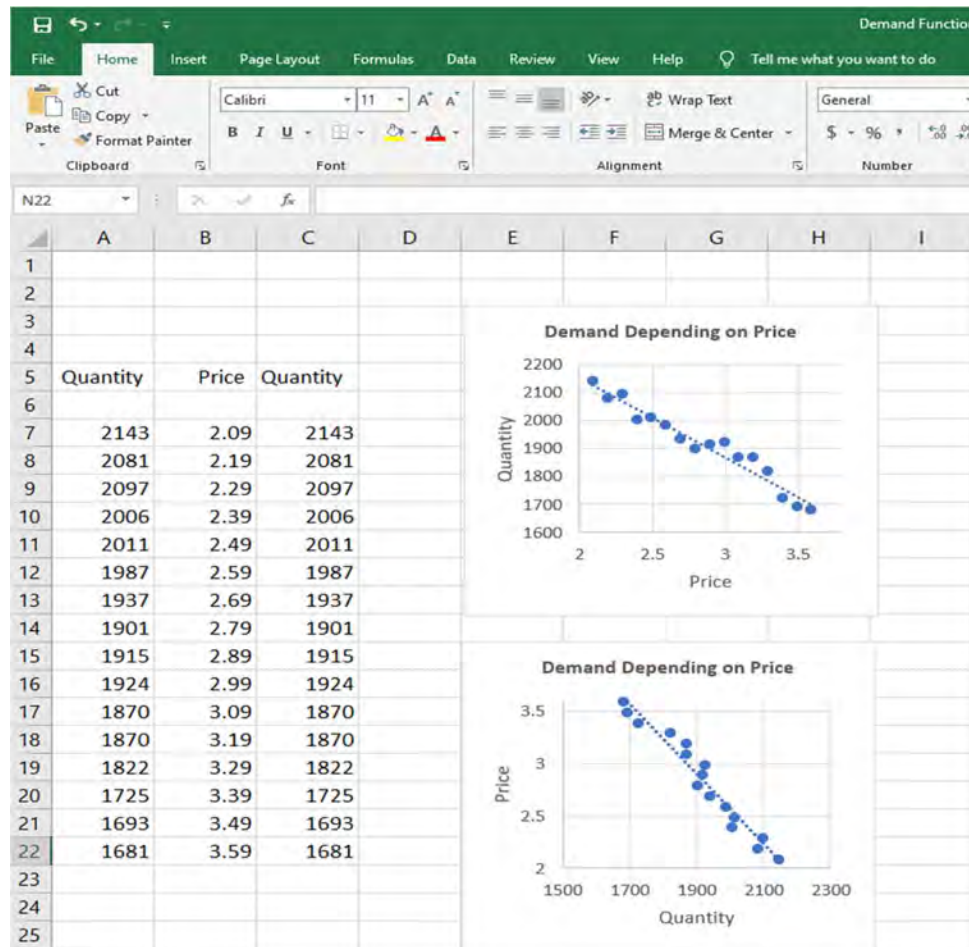


Figure 8: Identification of a demand curve

TEACHING ONLINE VS. TEACHING IN PERSON- COMPARISON: COSTS AND BENEFITS

As we learned this summer, *synchronous* online instruction – regular Zoom classes in conjunction with an asynchronous platform (such as Moodle, Blackboard, or equivalent) – is as effective as, or better than, in-person instruction.

Within this framework our experience of seven months, from March to September 2020, of teaching exclusively online because of the pandemic have shown to us that the online teaching model has not only costs but also benefits.

The main costs have been as follows:

- impossibility to use library resources, computer laboratories and copy machines, the colleges being closed;
- limited contact between students and administrative services;
- very significant difficulties in advertising for recruitment caused by the impossibility to have face-to-face discussions between recruiters and potential students, and the drastic reduction of subway and bus ridership, making subway and bus advertising useless;
- the potential students' reluctance to register to a college that is supposed to offer regular face-to-face courses but that offers in fact only online courses; and
- the steep intensification of the competition between private colleges used to provide traditional in classroom education and the exclusively online universities caused by the significant difference in tuition for providing the same type of service.

In parallel, the benefits of teaching exclusively online have been as follows:

- retention of those students who would have discontinued their studies for fear of coming to the college because of the pandemic;
- registration of new students who had agreed to take exclusively online classes but would have not agreed to take face-to-face courses during the pandemic;
- very significant time savings for students, faculty and administrative staff taking into consideration that the average time for two-way commutation in New York by using subway, bus or both is about one and a half hour (Kolomatsky, 2018);
- students' results as reflected in grades as good than those obtained during face to face in classroom instruction;
- development of less formal, friendlier relations among students and faculty in the case of Zoom, the students having the feeling that they are invited in professor's living room instead to be in the formal setting of a college classroom; and
- financial savings by the college due to reduction of some administrative staff and utilities.

In our opinion the synchronous courses using Zoom and Moodle or an equivalent software are the closest in efficiency to the in-person courses. They are undoubtedly superior to all other types of online courses, and although they do not offer the same level of socialization as in-person courses, they have some advantages in comparison with those courses that cannot be neglected.

Besides the obvious advantages of being offered during a pandemic without any risk of infection, the synchronous online classes allow considerable savings in commuting time in the case of the colleges and universities located in big cities and excellent higher education for students living at long distance or in remote areas. They can also attract a considerable number of foreign students who want to receive a very good higher education and are able to pay the tuition but cannot afford to come into this country because their financial means are limited.

Expressing our views on methods of teaching online and our appreciation for synchronous courses using Zoom and Moodle, we are also aware that the selection of one method or another should be dependent on courses' specificity. In this way, it is probable that nearly all social sciences courses can be given synchronously, but the physics and chemistry courses requiring laboratory work as well as the medicine and polytechnical courses, should be offered as hybrid. The mathematics courses can be also offered as synchronous courses, but in a specific manner that is described below.

Taking into consideration these remarks, we recommend using Moodle (or Blackboard) for posting topics to be studied, readings and assignments, as well as for receiving completed assignment from students. But we stress that for students and professors, Zoom + Moodle is a greater teaching methodology considering:

- Savings in transportation time and costs.
- Better classroom attendance and a safer teaching environment during the pandemic.
- A more pleasant teaching atmosphere during the pandemic.
- Infinite white board space: no need to erase information and easy retrieval of information from previous boards.
- Ability of students to audit sessions in other courses.
- Opportunities for students to “meet” between classes for small-group study.
- Increased *socializing* between classes.

For the college, the many advantages of teaching through Zoom + Moodle include the following:

- Ability to consolidate classes and increase class size.
- Lower operational costs.
- More satisfied students, according to our discussions with many students and the fact that at MCNY most student most students registered for the fall semester.

THE POST-PANDEMIC FUTURE

The economic and social effects of Covid-19 pandemic are comparable to those of other major tragic events of American history. But as happened in the past, it is highly probable that this nation will be able to defeat this major crisis and to become more powerful in its aftermath.

After the Civil War the American system of social, political and moral values became unitary, and the economic growth of the republic was so high that in 1892 the U.S. economy became the largest in the world, this country's GDP surpassing the GDP of the United Kingdom. (Haddow, 2008) In the aftermath of the Great Depression were established the bases of the welfare state and the creation of social security system. During and after World War II, the United States' economic, military and political power grew rapidly, this country being recognized after 1950 not only as a great power, but as a super-power.

By the same token, during the tumultuous years of the Vietnam War, America was able to put humans on the Moon and 15 years after the humiliating end of that tragic war the communist system collapsed in Eastern and Central Europe. Two years later it also crashed in Soviet Union and the former communist superpower disintegrated. That brief period remained known in history as the "unipolar moment," (Krauthammer, 1990) and since then the United States has been the sole super-power, its aggregate power – economic, military and political – being unmatched by the aggregate power of any other country.

Remembering these historical events and considering the American nation's resilience and creativity, it is normal to expect that the changes generated by the Covid-19 pandemic will be remarkable. It is obvious that like the other pandemics, this one will also end – probably by the end of 2021 or during the spring of 2022. But the economic and social life after the pandemic will not be the same as before.

The driving force behind the changes – both economic and social – will be the modification in the structure of aggregate demand. Those corporations, institutions and private providers of goods and services who will respond to the new types of demand will survive and prosper. But the ones who will be waiting for the return of a completely unchanged pre-pandemic demand will decline, go bankrupt or perish.

CONSIDERATION FOR COLLEGES: TEACHING OTHER COURSES THAT REQUIRE MATHEMATICS

Our positive experience in teaching mathematics and business courses online suggest to us that other courses requiring mathematics can be successfully taught online. Among these are the courses on mathematical statistics, applied statistics and theoretical physics as well as mathematical modelling in various areas of scientific inquiry. These might be social sciences like macroeconomics, microeconomics, sociology, international security analysis or strategy, and physical sciences like meteorology or ecology.

Teaching advanced economics and international relations courses at master and doctoral levels requires good knowledge of differential and integral calculus, differential equations, dynamic

system theory, and mathematical methods of optimization. In parallel mathematical simulation and quantitative analysis require basic to medium knowledge of numerical calculus and computer programming.

But, unfortunately, in the contemporary United States, the mathematical education in high school and in many undergraduate programs is limited or very limited. (Klein, Rice & Levy, 2012) As a result, true advanced economics and international relations courses that necessarily require the use of advanced mathematics are not offered, or if they are given, they are “advanced” only with regard to their name but not to their content. They use numerical examples to prove particular, instead of general, properties and relations that would have been previously proved by using appropriate mathematical methods.

Under these circumstances, teaching online by using simultaneously Zoom and Moodle (or other similar software) could facilitate the offering and learning of courses requiring the knowledge of advanced mathematics for several reasons. Between the classes, students could meet and study in small groups using Zoom.

From the students’ perspective, taking courses online increases their familiarity with technology, and develops their propensity and ability to think in a rigorous logical manner. Consequently, they become interested in using computers for solving problems that they had not considered before as being resolvable by using quantitative analysis. In this way, understanding the utility of mathematical knowledge and reasoning, many students have the tendency to spend more time for increasing their proficiency in mathematics, and as a result they become able to take advanced courses requiring mathematics.

From the professors’ perspective, teaching online courses in economics and international relations requiring advanced mathematical knowledge might be also interesting and attractive for several reasons.

This method of teaching allows the split of a three-hour course in two equal sessions or in a lecture of two hours and a problem-solving seminar of one hour without any programming difficulties and addition of commuting time. Such a split is useful in courses requiring mathematics because the students have sufficient time between the two sessions to understand various mathematical subtleties and calculations techniques presented during the lecture and on this basis to work on applications during the seminar.

The method is also useful for computer simulation of domestic and global economic processes, strategic situations, economic or military crises, etc. Testing and analyzing various scenarios proposed by students usually required more time than that allocated to a usual in-person session. Therefore, doing the simulation at home, and combining a synchronous lecture with an

asynchronous seminar might be beneficial for both, professors and students. For professors, because they could give to their students all the knowledge that they want to convey to them, and for students because they could contact their professors easily.

Taking into consideration that there are often significant differences in students' mathematical background, the professors can offer online tutorials or increase the duration or frequency of the online equivalent of office hours without too much additional effort.

CONSIDERATION FOR COLLEGES: RECRUITMENT AND RETENTION

Under these assumptions, institutions of higher education face and will face considerable challenges, the aggregate demand for higher education being essentially affected by three main factors. One is the change in students' preferences determined by the experience accumulated in taking online courses using advanced online teaching methods. Another one is the development of psychological and social habits associated with working from home. And the third factor is the decline in income caused by the pandemic. The influences of these factors are conjugate, and they must be considered in analyzing recruitment, retention, tuition structure and advertising.

With regard to recruitment, the recruitment officers should take into consideration that during the last seven months most high school students were taking classes online and many employed people were working from home. Consequently, they became relatively well familiarized with learning and working online and are able to assess its advantages and costs.

Depending on the method of teaching online, they might assess their learning experience in itself by comparing it with in-person instruction. But regardless of how they evaluate their learning experience, they appreciate the time and cost savings caused by elimination of commutation to college, as well as the opportunity to supervise any children they may have.

The students also appreciate the ability to access the saved Zoom lectures at any time and as many times as they want, and the decrease of the formality of the professor-student relationship in the classroom. A Zoom lecture or a Zoom meeting attended by students and professors staying in their living rooms and being casually dressed is psychologically relaxing and allows in some cases a better concentration on the discussion topics than a traditional in-person session in a college classroom.

Concerning retention, colleges should consider that in nearly all cases their students had taken online classes for periods ranging from three months to six or seven months and have developed sufficiently clear opinions regarding the value of different types of online teaching and learning. As a result, they are comparing the financial and social costs of continuing at the same college with those implied by the transfer to another college. In this context, if they do not live in the city

where the college is located, the students consider not only the tuition but also room and board expenditures, and these expenditures are considerable in the big cities.

Subsequently the decision of continuing to study at the same college or to transfer to another one is based on a cost-benefit analysis, and the college administrators must do their best in order to understand students' criteria of assessment and decision making. Proper understanding of these factors will help colleges maintain or increase retention level; neglecting them will result in lower retention.

CONSIDERATION FOR COLLEGES: FINANCIALS

Strongly associated with recruitment and retention is the tuition. The amount and structure are becoming today even more important problems for colleges and students than they had been before the pandemic. The main causes are the tough competition with the strictly online universities that offer lower tuition, and the steep decrease in income caused by pandemic. Under these circumstances, traditional colleges should increase programs flexibility and differentiate tuition depending on the programs' characteristics.

For example, a college might offer in the same field of specialization the following types of programs, the tuition decreasing from top to bottom:

- all courses are given in person;
- some courses are offered in person and some courses online, using Zoom for lectures and meetings, and Moodle or equivalent software for posting syllabi, discussion topics, reading resources and assignments, as well as for receiving students' completed assignments;
- all courses are given online using Zoom and Moodle or equivalent software, and complete access to all college physical facilities like libraries, reading rooms, computer rooms, laboratories, sporting halls and fields, etc.;
- all courses are provided online using Zoom and Moodle or equivalent software without access to college physical facilities.

In parallel both colleges and universities that have graduate programs besides the undergraduate ones might increase the attractiveness of their graduate programs by offering tuition reduction to their former undergraduate students interested in enrolling in graduate studies.

CONSIDERATION FOR COLLEGES: ADVERTISING

Finally, new advertising methods should be promoted, or the focus should be changed from one method to another. For example, observing that in New York City subway and bus ridership has decreased vertiginously during the pandemic, the colleges should concentrate on advertising online. At the same time more money should be spent for international advertising, taking into

consideration that many international students would like to have a degree from an American university and would be able to pay the tuition but would not be financially able to come and live in the United States.

Advertising flexibility and diversity should increase, and content should be enlarged to appeal to a wider audience. Besides the traditional objectives, advertising should also focus on the following ideas:

- the courses offered by using Zoom and Moodle or equivalent software are as good as the in-person courses;
- the students have the freedom to move from online programs to in-person programs and vice-versa without financial and administrative penalties;
- the Zoom meetings allow reasonable socialization; and
- the colleges take into consideration students' financial interests, and subsequently promote fair tuition policies by charging different tuitions for in-person, online and hybrid courses.

CONCLUSIONS

These are a few suggestions that we would like to make on the basis of our experience of exclusively teaching online for seven months. We are aware that the colleagues from around the country have accumulated an interesting and challenging experience since the beginning of the pandemic. Consequently, we believe that the publication of their ideas and suggestions would be very valuable for the advancement of higher education, and we invite them to join the discussion.

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