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WIP: Problems and Promises of Online Lectures for the Mechanics of Materials related Courses during and after COVID-19

Jayanta K. Banerjee (Professor)

Professor of Mechanical Engineering at the University of Puerto Rico in Mayagüez (UPRM).

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ABSTRACT

Since March 2020, when the COVID-19 problems started in teaching at the university level, I have been offering three courses, all related to the Mechanics of Materials, starting with elasticity, yield strength, plastic instability and fracture mechanics of some manufacturable solid materials, and the lubricants and coolants applied to their processes. Before the pandemics, I used to bring into *my in-presence* classes a lot of materials for demonstration and used to hand them over to the students for observation, and for touching and handling them in order to get some "feelings". For example, in the Manufacturing Processes course, I would bring some products made of bamboo, such as a set of cutleries made in Thailand, and pass them over to the students as an example of *"Green Manufacturing*" for sustainable, pollution-free manufacturing processes. Similarly, during the course on Tribology, I presented cans of contamination-controlled industrial coolants and lubricants, as well as examples of chemically corroded manufactured products for the lack of proper pollution-free storage environment. While by no means these are laboratory courses, such *on-the-table* demonstrations help the students develop consciousness on sustainable, pollution-controlled development in such courses where the *mechanics of materials* and its proper use are of utmost importance. In an online lecture such a direct presentation of the artefacts, as in archaeology, in front of the students is missing!

Undoubtedly, there are many promises of online lectures in the future of *distance learning*. A few years ago in a TIME magazine article, Dr. Rafael Reif, President of MIT, noted that online teaching would be easier for the students and less expensive for the university. In asynchronized classes, for example, the students could work fulltime during the day and read the recorded lectures at night, or *vice versa*. Furthermore, students, especially those with young families, don't have to move from place to place, from semester to semester, between the workplace (probably in a different city!) and the college campus. There are other advantages, both for the students and for the university. The expenses are cut down in "*virtual labs*"! But can they replace a "real lab" experience where accidents happen that don't occur on a laptop screen? Our Work-in-Progress (WIP) study will try to answer some such questions based on our lecture and lab experiences in the coming semesters. The current paper is an introduction to the problems and promises.

Key words: mechanics of materials, green manufacturing, tribology, distance learning.

Introduction

There is a well-known saying in Bengali, my native tongue: **Wherefrom comes the fear of a tiger, there falls the night** (*Jekhané Bagher Bhoy, Sekhanei Sondhya Hoy*). This is exactly what happened on March 13, 2020! The lecture classes and the in-presence labs all on a sudden stopped at the advent of

COVID-9, while we were struggling in preparation for the ABET accreditation of our engineering undergraduate programs. Those of us who had no previous experience in the *distance learning* type of instruction, had to start offering courses online with haphazard juxtaposition of class lecture notes, textbooks, and reference materials, all loaded on a laptop screen. In the following semester after the summer break, during August – December 2020, we took a crush course on how to offer classes and labs online. *And that course was also given only online! We were more confused than convinced. Yet it helped!* We practiced more on this sandwich course, and we devoted more time and energy with the usual enthusiasm and frustration of a newcomer, and finally got a certificate (after a lot of homework assignments and a final exam!) which confirmed that we were now "*legally permitted to offer online classes and labs*". Of course, this certificate was given only to those who passed the exam! Hence, we could feel the hurdle, disappointment, and frustration of the students!

In the third successive semester, January – May 2021, the situation improved a bit as the students helped their older instructors like me, in navigating through the rough waters of Internet problems, power failure, and so on. I still don't know how I conducted the online partial and final exams while keeping an eye on "online copying" of my students! During the current semester, after two consecutive COVID-19 Summers, some of us - the older professors – are now feeling a little bit more comfortable by practicing hard over the last three consecutive semesters, but a sense of *"Nature abhors vacuum*" is still there for not being able to engage ourselves in a direct mentor-mentee, preceptor-disciple, *Guru- Sishya* connection with our students within the ambience of a lecture hall or a lab floor.

There are many arguments to present on how the US Airforce simulation labs conduct practice for their jetfighter pilots, or how a neurosurgeon in New York City guides a brain operation at a hospital in New Delhi. These very successful experiments were designed, implemented, and tested with maximum careful caution over many years before their application in a very lucrative worldwide commercialization, both in army and in medicine. In the realm of classroom and lab instructions at a university level, COVID-19 appeared very suddenly as a bolt from the blue. We are collecting numerical data during the past, current and the coming academic semesters in order to present the pros and cons, the promises and the problems of this relatively abrupt transition from in-presence to on-line courses. As a WIP paper, we hope to present some of the statistical analysis of our data in a future presentation.

The Undergraduate Course on Manufacturing Processes:

This course is offered in the Junior year of Mechanical Engineering Undergraduate program, but the course is also compulsory for the Industrial Engineering Undergraduates. A course *on Mechanics of Materials* in a prerequisite for this course and is offered by the Department of General Engineering that also offers parallelly a similar course on Fluid Mechanics. Thus, the amalgamation of three departments, namely, Mechanical Engineering, Industrial Engineering and General Engineering (which is termed *Basic Engineering* in the US and Canadian engineering schools) had already made the situation complex for the students and difficult for their instructors, even before the calamity of COVID-19. In regular, conventional

classes, during the *in-presence* lectures and *on-the-table* demonstrations, such heterogeneity of background preparation among students coming from different departments, was partially controlled by the instructor [1]. While the Industrial Engineering (IE) undergraduates are more familiar with the statistical tools in data analyses and their interpretations (for having taken several courses in Statisticsand Probability Theories *a priori*, the Mechanical Engineering undergraduates are more familiar with the deterministic methods, and do not take any course on statistical methods, not even *a posteriori.*

This difference of background preparations in *Mechanics of Materials* as prerequisites and/or corequisites makes it difficult and sometimes uncomfortable in simply transmitting information, not to speak of transforming or converting information into the upper levels of *knowledge* and *wisdom* [2]. With the crisis of COVID-19, the situation became increasingly worse, since there was absolutely no direct face-to-face communication with the students in a visual, oral or verbal form. On-the-table demonstration of the artefacts, such as environmentally benign manufactured goods, were missing. Students couldn't ask questions or challenge the instructor at that very instant. Thus, the gap between the teacher and the taught, the professor and her/his disciples, the *Guru* and the mentees widely increased, and the quality of *Mastery Learning* deteriorated [3].

The Tribology Course for the Senior Undergraduates and the Graduate Students:

The word *Tribology* stems out of its Greek etymological root: *"Tribos",* meaning "rubbing". The course includes the concepts of friction (rubbing), its causes and consequences like relative motion between rubbing surfaces and their deterioration or wear. This course also focusses on lubrication and the lubricants for minimizing wear and thus improving the working life of mechanical components and systems. While the course is mainly addressed to the Mechanical Engineering Seniors, students from Physics, Chemistry and even from Biology register in this advanced Undergraduate cum Graduate level course. With the increasing research interest in Bio-tribology and Nano-tribology, much emphasis is given recently on the *Mechanics of Biomaterials.* Before the COVID-19 affected the in-presence lectures in March 2020, I used to bring in my class examples of worn-out animal bones and ligaments, as well as used to invite instructors from our Faculty of Nursing to offer special lectures on the frictional effects of blood in our veins and arteries. These 'practical 'demonstrations of tribology in a lecture class are missing, apart from the lack of physical contact in a Tribology lab [4].

The Graduate course on Advanced Machining:

This is a Graduate course, essentially on Materials Removal Processes, and the Mechanics of Materials under high strain-rate and at different elevated temperatures is of fundamental interest. Here again, students from other engineering disciplines register in this course, although the course syllabus is mainly focused on *the mechanical and thermal behaviors of machinable materials*. Before the pandemics, I used to take my students to the local machining factories, bring samples therefrom as well as fetch foreign examples from far-off countries. For example, the cutlery sets made of bamboo (made in Thailand)

were exposed to the students as a real example of “green manufacturing” by environment friendly and pollution-free materials and methods. Besides, cans of toxin-free cutting fluids during ultra-high-speed machining were brought in my classes as a table-top demonstration of benign machining. These ‘practices’ are not continued anymore in online classes [5].

CO-OP Courses:

The CO-OP students in our Mechanical Engineering Department usually have one on-the-job industrial mentor and an away-from-workplace academic mentor. While the on-the-job industrial mentor is in close contact with the student, the academic mentor works with her/him on a ‘remote control’ basis. Previously, I used to offer regular seminars for the CO-OP students, where the students used to present their CO-OP experience in the form of a written report and a verbal /oral presentation in class-room environment. I would invite CO-OP instructors from other engineering departments to take part in these seminars. It used to be a very dynamic academic and professional ambiance which is now discontinued during and after COVID-19, SARS-Cov and now their current version / variation of *Omicron*! In a CO-OP seminar we need more direct face-to-face dialogue with the students regarding their practical industrial experience that is not the same in an online environment!

Challenges and Promises of Distance Learning during COVID-19 and its Variations:

“Old order changes yielding place to new”, penned the British poet, Lord Tennyson. Any significant change offers new challenges and promises. Nevertheless, the worldwide transformation due to COVID-19 is very sudden, very drastic, and its effects in our education system have undeniably brought into action new challenges and novel promises and opportunities. In engineering, distance learning is not new, but it was limited within a specific circle of interested instructors and researchers. During COVID-19 online lectures and labs have become almost mandatory for instruction in both undergraduate and graduate levels. Its very sudden and drastic implementation has become a *challenge* for the ‘conventional’ instructors of the in-presence lectures and labs.

The promises of this challenge are multifaceted! Soon distance learning will be more widespread in engineering instruction, just as in medical and law schools. It will be well-implemented and accepted at all levels of engineering education, including teaching, research and services to the community that surrounds the university. As the President of MIT, Dr. Rafael Reif envisioned, engineering education would be better and cheaper. Let’s hope for the best!

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