From the Classroom to Home: Experiences on the Sudden Transformation of Face-to-Face Bioengineering Courses to a Flexible Digital Model Due to the 2020 Health Contingency

Jorge Membrillo-Hernández, Rebeca García-García, and Vianney Lara-Prieto

1 Escuela de Ingeniería y Ciencias, Tecnologico de Monterrey, Monterrey, Mexico jmembrollo@tec.mx
2 Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Monterrey, Mexico

Abstract. During these first months of 2020, the world is experiencing the most ruthless health crisis in modern history. This has led different areas of society to change their lifestyle or the way they are carried out. One of them is teaching, especially engineering education. This has required a sudden transformation of the methodology and the use of digital tools, as well as the training of teachers in an expeditious manner. The Tecnologico de Monterrey, one of the best private universities in Latin America, stopped its activities on March 20 to promote social distancing as a security measure against the COV19 (SARS-2-COV coronavirus) pandemic. This implied that at week 6 of the spring semester 2020, the courses would suddenly become a part of a newly implemented flexible digital model from home for both, the teacher and the student, preventing attendance to school facilities. In this manuscript, we analyze the response of 3 groups of specific subjects from the Bioengineering Department that were migrated. One of these subjects was precisely the Microbiology Laboratory for Engineers, which involved a major challenge. The teachers received adequate training for a week and students were then transferred to the new synchronous online model. Knowledge acquisition analysis and satisfaction surveys showed that the implementation of this digital model was adequate to achieve the academic objectives set from the beginning of the 2019–2020 academic year.

Keywords: COVID-19 · Challenge Based Learning · Educational innovation · On-line learning · Higher Education

1 Introduction

1.1 An Unexpected Event

In August 2019, at the planning meetings for the fall 2019 and spring 2020 semesters, we never imagined what would await us or that the face-to-face courses we offer would
have to be moved to a remote version. In December 2019, cases of a group of sick people with an unknown type of pneumonia were reported for the first time in Wuhan City, capital of the People's Republic of China [1]. Most of the affected individuals were workers at the Wuhan South China Wholesale Seafood Market [2]. The contagion curve and the epidemic became very dangerous and the world watched with amazement the increase in deaths and in the number of cases (Fig. 1).

The 2019–2020 COVID-19 is a pandemic derived from a coronavirus disease, caused by the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), identified as a highly contagious virus with high mortality. The cases quickly spread outside of China and countries like Italy experienced a rapid expansion of the virus in their population (Fig. 1). The World Health Organization (WHO) recognized it as a global pandemic on March 11, 2020 [3, 4].

As of June 6, more than 6.8 million cases of the disease have been reported in more than 213 countries and territories in the world (the five countries with the highest number of infected people are United States, Brazil, Russia, United Kingdom and Spain). More than 399,000 deaths (the five countries with the highest number are United States, United Kingdom, Italy, Brazil and France) and more than 3 million cases of people recovered (the five countries with the highest number of people recovered are the United States, Brazil, Russia, Germany and Italy).

The virus is usually transmitted from person to person through tiny droplets of saliva, known as Flügge microdroplets, which are emitted when speaking, sneezing, coughing, or exhaling. The virus spreads mainly when people are in close contact, but it can also be spread by touching a contaminated surface and after touching contaminated hands to the face or mucous membranes. The governments of the affected countries in the first three months of the year established home confinement, restricting mobility and thus restricting access to schools [4].

In March, the pandemic was growing in Europe (Fig. 1) and the countries of America were preparing their strategies to be able to face the imminent arrival of the pandemic to the continent. In Mexico, the first case of COVID-19 was reported on February 28, 2020, and as of June 7, the Government had reported 113,619 accumulated cases of infected people. How to react in an educational institution to this imminent event? What strategy to follow to give continuity to the courses initially planned as face-to-face and transform them to be online in the middle of the semester? For all education at all levels, it was a disruptive moment. In this manuscript, the results of the conversion of three face-to-face Bioengineering courses to online courses are presented. Our data indicate that, although they did not lose concepts, and all the topics were reviewed, the competency assessment was a difficult item for the teachers. The future of the pandemic is still uncertain, so is the date of return to the classroom, so we must be prepared for even greater challenges.
2 Scholar Settings

2.1 Courses Analyzed, Changing the Scholar Framework

On March 20, 2020, the authorities of the Tecnologico de Monterrey decided to close the 26 campus of the university nationwide, in an unprecedented action and becoming the first educational institution in Mexico to make a decision to protect the collaborators, students and teachers of the educational establishments. This decision was based on the need to stop the rapid spread of the SARS-CoV-2 virus causing COVID-19 disease [4]. At the time of submitting this document, there is still no date for reopening.

Thus, 92 thousand students from Tecnologico de Monterrey, more than 19 million Mexican students of all levels and, in general, the more than 1,500 million students worldwide stopped taking classes at their schools. It is known that the closure of schools may be (together with the prohibition of large public gatherings) the most effective measure to slow the progression of the disease [6]. This measure is particularly justified by the rapid spread of the virus in children and adolescents, which could be even greater than in adults [7]. Teachers who took this pandemic by surprise are still unaware of the implications this measure will have on student learning and what will happen when schools reopen. At this point, we can report on the interrupted courses and analyze their performance measures.

On March 20, by interrupting classroom activities, the Tecnologico de Monterrey took a week (from March 23 to 27) for teacher training. Table 1 establishes the different training topics to which the teachers were subjected. It does not escape to our attention that the current situation reveals several problems that the Mexican educational system in general has to face: The crisis has forced the migration of educational systems to online mode immediately and abruptly, which has given rise to a “remote emergency teaching” [8]. The current crisis leaves no room for planning and designing the learning

![Accumulative Confirmed Cases](image)

**Fig. 1.** Accumulative confirmed cases of COVID-19 in three different countries. The date of the data is shown in the X-axis and the accumulative number of cases is depicted in the Y-axis [5]
experiences that characterize authentic online education. Very important, it is necessary to reflect on how the end of the course would be evaluated.

The initial hypothesis implied that after the closure of schools, there would be a negative impact on the learning of all students; and on the other hand, this impact will be much greater for students from environments with difficulties to access information and communication technologies (ICT). The sudden migration of teaching activity from the face-to-face model to the online model shows the existence of three gaps [9]:

- Access gap (having or not having access to ICT devices).
- Use gap (Experience in its use).
- School gap (teaching skills, availability of resources and adaptation of online platforms to support teaching).

In the course schedule for the spring 2020 semester, it was determined that within the academic load, three courses would be implemented for Bioengineering students from the second and third semester, Biomimetics and Sustainability, Genetics and Microbiology Lab (Table 2). All courses would have the engineering vision required for the objectives of the Tecnologico de Monterrey, one of the best universities in the world (155 according to the QS ranking of 2021) and the best private university in Mexico.

| Course                      | Teaching Technique        | Remaining sessions after the break |
|-----------------------------|---------------------------|------------------------------------|
| Biomimetics and Sustainability | Challenge based learning   | 14                                 |
| Genetics                    | Project based learning     | 14                                 |
| Microbiology Lab            | Practical based learning   | 7                                  |

Table 2. Courses analyzed in this research.


3 Results and Discussion

3.1 Biomimetics and Sustainability

This course is designed under the Challenge Based Learning technique in the new Tec21 model [10]. Students analyze the problem, seek an answer in a multidisciplinary environment and develop transversal competencies such as collaborative work, critical thinking and resistance to failure; on the other hand, disciplinary competencies are developed such as integrating the concept of sustainability, clean and renewable energy into different solutions to challenges.

Thirty-one students were taking the classroom course when it was decided to convert the course into a distance course due to the COVID-19 pandemic. The lecturer of the course was trained in ZOOM and SOCRATIVE (Table 1) to continue with the course. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam; this is after 14 online sessions. The most complex part of this course is solving the previously established challenges [10–14] only with online resources; one in particular had an extensive discussion regarding the engineering principles of the biophilic model of a football stadium.

3.2 Genetics

This course is designed under the technique of Project Based Learning, where students develop investigations that solve a problem previously explained in class, the concepts are discussed and the evaluation rubrics of the projects to be developed are established. Transversal competencies such as collaborative work, critical thinking and information search are developed. On the other hand, disciplinary competencies are developed such as the integration of technical concepts such as PCR, Microarrays, and fundamental bases of genetic engineering. This particular course was of great interest on the part of the students due to the situation of the pandemic.

Twenty-five students were taking the course in the classroom when it was decided to convert the course to a distance course due to the COVID-19 pandemic. The course teacher received training in ZOOM and TEAMS (Table 1) to continue the course. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam, the last two were carried out after 14 online sessions (Table 2).

3.3 Microbiology Lab

Two groups of this course (21 students in total) carried out their 7 remaining practices in an online mode. This class was a very difficult challenge for the regular teachers of the course because it is not easy to develop laboratory skills in a virtual environment. It was possible to obtain licenses from different simulators of laboratory techniques; this did require a collegial effort by all the teachers at the national level to be able to carry out the practices.

The Microbiology Laboratory course is designed under the technique of Practical Based Learning, here students follow a path to carry out the practices and are evaluated afterwards to establish a performance rating. The tenured teachers were not
only trained in ZOOM and TEAMS (Table 1) to continue the course, but also in various simulators of bacterial growth and in biotechnological process engineering. Figure 2 establishes the grades obtained by the students during their last (third) grading period and final exam; the last two were done online during 7 sessions (Table 2).

![Group average](image)

**Fig. 2.** Average achievement of the groups of the three courses studied. **Group AVG** describes the group’s average grade during the face-to-face weeks before switching to online classes. **Third partial** and **final** grade are using ICTs.

### 3.4 Conclusions

Our data clearly indicates that the hypothesis of a drop in student achievement was not true in any of the three courses studied. The Genetics course, under the **Project based learning** technique, was the most affected course, compared to the Laboratory course that is designed in **Practical based learning**. It is notable that the Biomimetics course, offered under the **Challenge based learning** technique, apparently did not have an impact on the grades, which implies that the resolution of challenges perhaps has more to do with finding the solution rather than with the method used. This is consistent with previous reports [13, 14].

Our results indicate that at least students responded robustly to the sudden change in teaching, from an on-site class to an on-line class. More studies have to be done to establish whether teachers and students find improvements in distance learning teaching-learning techniques. Special attention is given to the laboratory course that opens an area of opportunity little explored, to have virtual laboratories with only simulators.

**Acknowledgments.** We would like to acknowledge the financial and the technical support of Writing Lab, TecLabs, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this work.
References

1. Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X.: Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395(10223), 497–506 (2020). https://doi.org/10.1016/S0140-6736(20)30183-5

2. Lau, S.K.P., Luk, H.K.H., Wong, A.C.P., Li, K.S.M., Zhu, L., He, Z., et al.: Possible bat origin of severe acute respiratory syndrome coronavirus 2. Emerg. Infect. Dis. (2020). https://doi.org/10.3201/eid2607.200092

3. https://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/

4.WHO Director-General’s opening remarks at the media briefing on COVID-19—11 March 2020. World Health Organization, 11 March 2020. https://data.europa.eu/euodp/es/data/dataset/covid-19-coronavirus-data

5. Markel, H., Lipman, H.B., Navarro, J.A., et al.: Nonpharmaceutical interventions implemented by US cities during the 1918–1919 influenza pandemic. JAMA 298(6), 644–654 (2007). https://doi.org/10.1001/jama.298.6.644

6. Prem, K., Flasche, S., et al.: The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. Lancet Public Health 5(5), e261–e270. https://doi.org/10.1016/S2468-2667(20)30073-6

7. Hodges, C., Moore, S., Lockee, B., Trust, T., Bond, A.: The difference between emergency remote teaching and online learning. Educ Case Rev. (2020). https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

8. Fernández-Enguita, M.: Una pandemia imprevisible ha traído la brecha previsible. Cuaderno de Campo (2020). https://blog.enguita.info/

9. Membrillo-Hernández, J., Ramírez-Cadena, M.J., Caballero-Valdés, C., Ganem-Corvera, R., Bustamante-Bello, R., Benjamín-Ordoñez, J.A., Elizalde-Siller, H.: Challenge based learning: the case of sustainable development engineering at the Tecnologico de Monterrey, Mexico City Campus. In: Auer, M., Guralnick, D., Simonics, I. (eds.) Teaching and Learning in a Digital World. ICL 2017. Advances in Intelligent Systems and Computing, vol. 715. Springer (2018). https://doi.org/10.1007/978-3-319-73210-7_103

10. Membrillo-Hernández, J., Muñoz-Soto, R.B., Rodríguez-Sánchez, A.C., Castillo-Reyna, J., Vázquez-Villegas, P., Díaz-Quiñonez, J.A., Ramírez-Medrano, A.: Student engagement outside the classroom: analysis of a challenge-based learning strategy in biotechnology engineering. In: Proceedings of the EDUCON 2019. IEEE Global Engineering Education Conference, EDUCON April-2019, 8725246, pp. 617–621 (2019)

11. Membrillo-Hernández, J., Villalobos, T., Ramírez-Cadena, M.J., Martínez-Acosta, M., Cruz-Gómez, E., Muñoz-Díaz, E., Elizalde, H.: Challenge based learning: the importance of world-leading companies as training partners. Int. J. Interact. Des. Manuf. 13, 1103-1113 (2019). https://doi.org/10.1007/s12008-019-00569-4

12. Membrillo-Hernández, J., Ramírez-Cadena, M.J., Caballero-Valdés, C., Ganem-Corvera, R., Bustamante-Bello, R., Benjamín-Ordoñez, J.A., Elizalde-Siller, H.: Challenge based learning: the case of sustainable development engineering at the Tecnologico de Monterrey, Mexico City Campus. Int. J. Eng. Ped. 8, 137–144 (2018). https://doi.org/10.3991/ijep.v8i3.8007