

CHALLENGES FACED BY UNIVERSITY PROFESSORS WHILE TEACHING STATISTICS ONLINE DURING THE COVID-19 PANDEMIC

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This study explores the numerous challenges that university professors have faced in teaching statistics courses online during the COVID-19 pandemic. It is part of a broader research project that explores characteristics of statistics teaching in university education. For this research, we designed a questionnaire that was answered by 750 statistics professors from 420 Mexican universities. The challenges they faced involve: (a) the use of information and communications technology; (b) technological tools for teaching statistics; (c) data; (d) the online learning environment; (e) students' knowledge; (f) statistical projects; (g) curricula; (h) attitudes; (i) the application of statistics; (j) the professors' pedagogical content; (k) assessment; and (l) financial resources. Results provide us with a broad picture of the many challenges involved in teaching statistics online.

INTRODUCTION

The worldwide contingency derived from the appearance of the SARS-CoV-2 coronavirus, commonly known as COVID-19, generated new scenarios in educational activities. In Mexico, containment was officially decreed in March 2020, and face-to-face classes were suspended in all educational institutions in the country, affecting approximately 33 million students enrolled in 274,000 schools and almost two million teachers (Ruiz Muñoz et al., 2021). Confinement meant migrating to a virtual modality, though in some cases the pedagogical practices from face-to-face classes were maintained. That is, the modality was modified, but the usual practices of face-to-face work continued, including rigid schedules and the same number of program courses (Miguel Román, 2020). Confinement also forced professors to exchange the traditional classroom for a new personal space that affected their academic, social, and family dynamics, and brought on personal, economic, emotional, and health pressures (Chávez-Sánchez et al., 2020; Sánchez Mendiola et al., 2020).

To continue with their teaching practice, professors had to make use of technological platforms and digital tools (Sánchez Mendiola et al., 2020), a change that highlighted their needs and limitations in managing these technologies (Chávez-Sánchez et al., 2020). Similarly, deficiencies were evidenced in many educational institutions in terms of, for example, internet connectivity, lack of technological resources, and scarce didactic-creative training in the use of technologies for professors to allow professors to perform work virtually (García, 2021).

The teaching of statistics online has been a challenge for professors due to a need to effectively implement computer tools. Using appropriate technological resources, professors can implement online activities that promote active learning, use software that fosters the understanding of concepts and data exploration, establish closer communication with students, and conduct tests or assessments more efficiently (Schwartz et al., 2018; Tsami, 2021). Therefore, the importance of identifying an appropriate selection of platforms that facilitate statistical learning online has been highlighted, as has the need to improve student–professor interaction to enhance the study experience and allow monitoring of the formative and summative assessment processes (Mills & Raju, 2011).

The COVID-19 health crisis and mandatory confinement revealed that online education—in statistics and most other subjects—presented challenges that significantly impacted the educational process. According to Sánchez Mendiola et al. (2020), these challenges can be classified as: (a) logistical (time management, class schedules, physical spaces, and institutional communication, among others); (b) technological (internet access, access to equipment, and management of educational platforms); (c) pedagogical (lack of knowledge of at-a-distance didactic tools, student evaluations, among others); and (d) socio-affective (emotional, affective, and health related).

In the context of the pandemic, we developed a study with the goal of characterizing the teaching and evaluation of statistics education at the university level. As part of this study, we explored the main challenges that university professors who teach statistics in Mexican institutions faced during the pandemic. We report on these challenges in this article.

THE STUDY

The study forms part of a broader project whose objective was to characterize the teaching and evaluation of statistics education at the university level. To identify salient characteristics, a questionnaire was designed based on the six recommendations of the American Statistical Association (ASA) in their *Guidelines for Assessment and Instruction in Statistics Education (GAISE)* (GAISE College Report ASA Revision Committee, 2016). The questionnaire included a total of 76 items: 52 content items related to the GAISE guidelines (teaching statistical thinking, focusing on conceptual understanding, integrating real data with a context, fostering active learning, using technology, and assessments); 22 on sociodemographic data and variables related to professional status (e.g., age, gender, information on the groups the professors taught, professors' academic background, etc.); and two open-ended questions.

The process of applying the questionnaire was carried out between December 2020 and July 2021. For this purpose, e-mails were sent to the directors, sub-directors, and coordinators of public and private universities that belonged to the National Association of Universities and Institutions of Higher Education and Higher-Level Technological Institutes (ANUIES for its acronym in Spanish). The message requested support from directors in extending the invitation to answer the online questionnaire to all statistics professors. A total of 750 professors responded.

The results presented in this report come from one of the two open-ended questions; namely, *What are the challenges you currently face in your statistics courses?* This item referred to challenges in general. Most of the teachers mentioned more than one challenge but not all of them seemed to be concerned about the COVID-19 pandemic. We report only those responses related specifically to challenges resulting from the pandemic. Of the 750 teachers, 401 offered at least one such response, for a total of 627 ($n = 627$). We performed a qualitative analysis using the Atlas.ti 9 program (<https://atlasti.com/>). As suggested by Kalpokaite and Radivojevic (2019), this analysis consisted in examining the content of each response and coding it according to the challenges that the professors mentioned. The codes assigned to the challenges were grouped into 12 thematic categories: (a) *use of information and communications technology (ICTs)*; (b) *technological tools for teaching statistics*; (c) *data*; (d) *the online learning environment*; (e) *students' knowledge*; (f) *statistical projects*; (g) *curricula*; (h) *attitudes*; (i) *application of statistics*; (j) *professors' pedagogical content*; (k) *assessment*; and (l) *financial resources*. These categories were based on the data collected (professors' responses) and represent, to a greater or lesser extent, the main challenges that the professors cited in their teaching of statistics during the pandemic.

RESULTS

Figure 1 shows the ascending percentage of the 627 responses associated with each one of the 12 challenges that professors mentioned regarding their statistics classes during the COVID-19 pandemic. Clearly, the main challenges are related to issues that involve the use of technology in general, the online learning environment experienced during classes, and students' attitudes. However, issues that we consider specific to the teaching of statistics also emerged, such as the use of technological tools to teach topics in statistics and opportunities to apply statistics both in class and outside the classroom.

Use of ICTs

Mentioned by 170 of the 401 professors, this category includes the challenges that the professors expressed mainly about internet troubles, the lack of technological resources for both students and them, and the lack of knowledge among professors and students in the use of Information Communication Technologies (ICTs). Some professors' responses that reflect these challenges include the following.

- [My students'] lack of knowledge in the use of statistical programs such as Excel or other graphical tools to perform activities is not a challenge if they are given some tutoring at the beginning, but this takes a lot of time. I would say that a quick solution is usually to share manuals or video tutorials, but sometimes not everyone [understands] so you have to do extra sessions in workshops on the use of Excel or other platforms. (Professor no. 183)
- Technologies are a challenge because many students report connectivity challenges or don't have the computer equipment they need to take their classes. Sometimes they do it from their cell phones with data service, but when that runs out, they can no longer attend. (Professor no. 280)

- More effective teaching–learning capacity and mastery of digital platforms and software. (Professor no. 679)

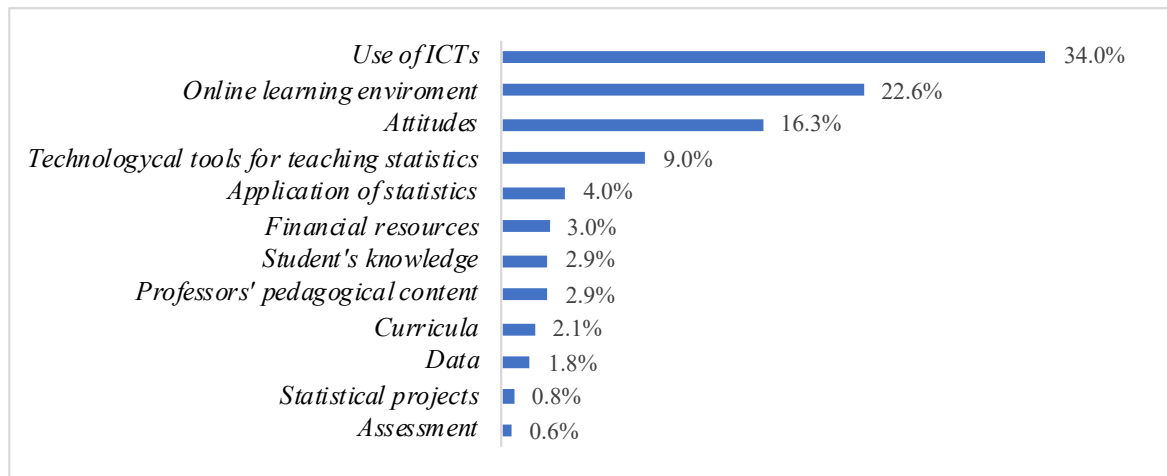


Figure 1. Major challenges that professors face in teaching statistics during the pandemic

The Online Learning Environment

Mentioned by 128 of the 401 professors, challenges reported in relation to this category refer to the environment of online classes, including interacting with students to explain content and monitor their work and adapting to this environment. Some of the professors' responses in this category follow.

- There's less interaction with students and it's more difficult to monitor the progress of their activities during classes. (Professor no. 185)
- I prefer to give face-to-face classes because I can look into the students' eyes and face and see whether or not they understand the topics or need more explanation. (Professor no. 191)
- It's more difficult to stimulate students to learn statistics. They weren't prepared for this type of learning. It's very difficult to organize them in work groups. (Professor no. 576)

Attitudes

Challenges related to attitudes were mentioned by 89 of the 401 professors. These challenges refer to a lack of student interest in the study of statistics and a lack of participation in, commitment to, or attention in their classes, as well as poor attendance. In this regard, the professors who responded made comments such as the following.

- There's little interest among students in this subject. They always hand in their work on the weekend before the end of the evaluation, when I can't give them feedback that would allow them to correct mistakes. They practically study on their own and few ask for tutoring. I offer it but few respond. (Professor no. 250)
- Psychological affectations in the students (due to the pandemic). Apathy, little interest in learning, sometimes no interest at all. (Professor no. 349)
- Maintaining the attention and real presence of students. Some are connected but absent. (Professor no. 245)

Technological Tools for Teaching Statistics

This category includes challenges related to the lack of statistical programs, perhaps because licenses are not obtained, professors are unaware of free software packages, or knowledge of the use of statistical programs among both students and professors is inadequate. On this topic, 57 of 401 professors commented on statistics teaching tools, including the following.

- Statistics programs are expensive. We only access them in test mode. (Professor no. 564)
- Previous training of students in information technology. Access to statistical applications for students (especially SPSS). (Professor no. 329)
- I'd like to be trained in more statistical management technologies. (Professor no. 248)

Application of Statistics

According to 24 of the 401 professors, the suspension of face-to-face activities affected the performance of laboratory practices, field data collection, and experimental designs, among other activities involved in applying statistics. It also made it more difficult to appreciate the importance of statistics for careers. The professors mentioned this among the challenges they faced.

- The approach to, and realization of, real practices. (Professor no. 105)
- The design of experiments in a real laboratory. (Professor no. 106)
- The biggest current challenge is to get students to perform field practices during the contingency. Data collection and applying statistics in organizations have become more complicated. (Professor no. 202)

Students' Knowledge

Another challenge cited by 18 of the 401 professors was the lack of basic knowledge in mathematics among students and a lack of understanding of this subject. They commented as follows.

- It's true that some students learn well on their own, but it's not common. Most find it difficult to attend to asynchronous instruction. Moreover, the fact that the middle level bases are not very good as scaffolding to support new knowledge [affects them]. (Professor no. 218)
- To provide minimum, but important, support in handling concepts of basic arithmetic calculations so they understand basic concepts like proportion, ratio, and subtraction. To destigmatize [the idea] that statistics is incomprehensible and boring with respect to clinical subjects, so in courses I work on applications in clinical practice for decision-making with patients, a community, a country. (Professor no. 549)
- Understanding the concepts of probability. 2) Due to the fact that access to information is sufficient, it's necessary to emphasize learning how to recognize reliable sources of data. (Professor no. 425)

Financial Resources

The pandemic accentuated the lack of economic resources among students, some of whom did not have the means to own or access adequate computer equipment or internet services to continue studying. In some cases, the lack of economic resources in families forced students to take jobs and attend classes during working hours. Eighteen of the 401 professors commented on finances, including the following comments.

- Some students don't own technology or have the money to pay for internet service. (Professor no. 155)
- Some work with cell phones [but] the pandemic forced them to get jobs, so they're online during working hours trying to capture the information. (Professor no. 281)
- Students' lack of economic resources pushes them to take jobs, sometimes with schedules that make it difficult for them to attend classes on the following days. (Professor no. 547)

Professors' Pedagogical Content

Another main challenge expressed by 17 of the 401 professors related to designing activities, educational materials, and pedagogical content suitable for use in the online environment. Some comments included the following.

- You need to prepare more for online teaching because it's more difficult this way. (Professor no. 368)
- Developing materials and educational videos suitable for the course. (Professor no. 217)
- Generating materials that students can understand easily. The need to be so detailed in explaining and using new technologies. (Professor no. 656)

Data

Another challenge presented by confinement that was mentioned by 11 of the 401 professors involved the use and collection of real data. The pandemic limited the possibility of conducting practices in the field so students could have experiences in collecting real data. The following are representative of professors' comments about data.

- When we were in [normal] classes, students took their own biological data, now it's more complicated. (Professor no. 30)
- The use of real data so that students confront real cases and can define which statistical methodology can be used to solve the problem. (Professor no. 387)
- Using statistical data that is as real as possible, and the importance of developing statistical analysis like, for example, statistical data on the pandemic. (Professor no. 102)

Curricula

With respect to this category, 11 of the 401 professors highlighted some challenges that arose in online classes related to the fulfillment of the objectives of study programs and the place of courses in the organization of curricula. Some of these challenges are described below.

- Lack of coherence in, and background to, study programs. (Professor no. 22)
- Inability to develop in depth the topics and activities marked in the program. (Professor no. 203)
- Flexibility of the subject content. (Professor no. 670)

Statistical Projects

The suspension of normal academic activities also prevented students from developing and carrying out statistical projects. This constituted an important challenge for the teaching of statistics identified by five of the 401 professors, including the following comments.

- That confinement limits students' ability to conduct research or laboratory projects. (Professor no. 215)
- The counseling of the projects that are carried out [because] students require personalized, face-to-face help. (Professor no. 657)
- Students' implementation of statistical projects like Six Sigma [and] Statistical Quality Control. (Professor no. 643)

Assessment

Another challenge during the pandemic centered on the application, monitoring, and feedback of the evaluation of academic activities. Four of the 401 professors expressed their concern about achieving student learning in the virtual modality. Three of them commented as follows.

- The impossibility of applying instruments like knowledge tests (due to institutional instruction and because at a distance there's no way to verify that students don't cheat). (Professor no. 108)
- How to verify that students really obtain the knowledge they need. Online exams have serious limitations when it comes to checking whether students are getting the knowledge they need. (Professor no. 327)
- How to evaluate evidence where exercises are required by hand. (Professor no. 696)

CONCLUSIONS

The COVID-19 pandemic brought to light numerous important challenges associated with online education. Although most of the challenges reported by the professors are not unique to statistics education, they involve characteristics that were impacted by the pandemic, such as data collection and the design of experiments in real-world settings. According to the professors, however, all the challenges they identified affected their statistics courses.

The main challenges that professors mentioned were related to technology, which coincides with the findings reported by Sánchez Mendiola et al. (2020). Other items in the questionnaire revealed that most of the 750 professors (96.3%) who responded to the questionnaire indicated that they use specialized software (Excel, GeoGebra, SPSS, Minitab, or R) to support their statistics classes, complemented by online resources (e.g., videos related to statistics, institutional or government repositories) as didactic materials. However, some of the 401 professors who identified COVID-19-related challenges reported that they lacked knowledge in the use of specialized software and/or their institutions did not acquire required licenses. Thus, the greatest challenge in relation to technology was not about the use of specialized software or online didactic materials but the deficiencies reported by Garcia (2021), which included internet connectivity, scarce technological resources, and limited knowledge of digital tools among professors that constrained their ability to work virtually.

The next two challenges most-often mentioned seem to be linked. Referring to the online learning environment, the professors reported that interaction with students was challenging because engaging with them and monitoring their participation during classes proved especially difficult. Issues with engagement and participation were also identified as attitudes shown by students working in the virtual modality, but some professors also noted that students showed little interest in studying statistics.

Though in varying degrees, all the challenges identified impeded fulfilling the recommendations for statistical instruction and assessment outlined by ASA in the GAISE report (2016). Given this background, our future analyses will focus on relating these challenges to the rest of the responses to the questionnaire to acquire additional information that will allow us to obtain an overview of the current state of statistics education at the university level in Mexico. The results reported here provide substantial knowledge of the key conditions that professors feel they require to strengthen their online teaching of statistics.

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