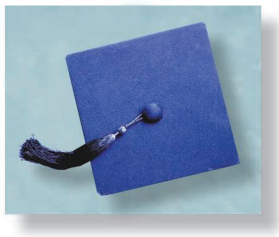

Educator's Corner

Teaching Microwaves in the Time of COVID-19

■ **Zhaolong Li**

The coronavirus (COVID-19) outbreak hit Wuhan, China, unexpectedly at a time that could not have been worse, just days before the Chinese lunar calendar Spring Festival, when millions of people were traveling. Buses were canceled; high-speed trains passed Wuhan without stopping; all businesses, banks, post offices, and indeed the entire city were shut down. A hospital with 1,000 beds was built within 10 days followed by a second hospital, and even the country's strategic forces were mobilized to support the front in the battle against the disease. All of these measures were taken because the most ancient and efficient method to stop an epidemic is to isolate the infected from the healthy. Everyone, the whole country, was asked to stay home to prevent the disease from spreading, and it proved to be effective. It took time for the public to realize the severity of the disease, but, once they did, quarantine policies were implemented voluntarily.

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Although people were physically isolated, their hearts and minds were warmed and connected to each other. For example, a determined 24-year-old community-clinic biolaboratory technician undertook a trip of more than 300 km by bicycle for four days and three nights when transportation was shut down to get back to her office at the epicenter of the outbreak. During the period when schools were shut down, a student climbed to the summit of a snow-covered mountain and sat on rocks so that she could have an

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Internet connection strong enough to attend network learning. Teachers at different elementary schools, high schools, colleges, and universities engaged in teaching courses through various platforms connected to the Internet from somewhere in the country. The course I teach, Microwave and Millimeter-wave Systems, was among them.

Teaching without seeing the faces of students was not easy, although the concept of the MOOC has been popular for years. Of course, as you may know from having watched some examples of MOOCs, many are footage recorded while the instructor lectures in a traditional classroom filled with students, which was not possible in our situation.

Frankly, the efficacy of learning microwaves just by watching a video is limited. The limitation was not a problem with platforms such as WebCT or other online teaching tools. These days, the available platforms offer many software tools that can be used to facilitate teaching. So what was it that made teaching via the Internet, and only via the Internet, difficult? It was the lack of the feedback and mutual interaction between the teacher and students that happens naturally in a classroom. Borrowing and adapting my title from the title of a novel [1] that reflects the current situation, this article shares what I learned about how we must change our teaching methodology to adapt to the web-oriented learning process.

Factors to be Considered for Web-Oriented Learning

When teaching online, several factors need to be taken into account.

1) *How to keep students focused on the lecture*: In a classroom where students are gathered together, they are forced to concentrate on the instructor. However, when students stay home and connect to the teaching resource through their computer or cell phone, how do you keep them focused when there could be many distractions?
2) *How to get feedback from students*: This is so easily done in a traditional classroom. Now, as an instructor, I need to connect to 165 students through the optical cable under my desk. What can I do to open a discussion and interact with them?
3) *How to evaluate a student*: Clearly, a microwave engineering course is not like a language course, for which you can set up a computerized standard test where exam time, style (open/closed/semiclosed book), and answers can be controlled accurately. Evaluating an engineering course exam sheet involves the judgment of students' intermediate steps to see whether they are on the right track to solving a problem (i.e., answers for subjective problems cannot be evaluated automatically).

In answering, I kept asking myself a simple question: How should I organize the teaching? As a result, I used the available computer gadgets, but I didn't rely on them. I focused instead on how to teach students something within the limited capacity of only a small LED screen. Let me elaborate.

First, I broke down my 50-min class into small minilectures with a duration of 10–15 min each. Of course, modern online teaching platforms allow the instructor to force the student's screen to display designated video clips while making the student unable to switch windows. I found that this way of controlling the students' computer screens resulted in limited motivation on their part. Studies show that, in this cellphone age, people's ability to remain focused on something is in the range of 10–15 min. I kept this rule in mind and shot my own teaching footage to fit this time frame. An example, in Chinese, can be found at [2].

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Second, I added practical elements to attract students' attention. For example, explaining a radar equation could be boring on a small screen; making a radar demonstration is not. I built a Doppler radar to detect a moving target, such as a corner reflector or a dancing me [2], to show to the audience and encourage students to find out about the principles of a Doppler radar for themselves. The key to attracting students' attention and keeping them focused is to discuss one topic within one video clip. Meanwhile, by checking the viewing metrics, the instructor can get an idea of where the students' interests lie and improve his or her teaching accordingly. Upon doing so, I managed to deliver the course to students' screens using segmented time modules during the school day.

Third, I redesigned my exam to suit a situation where I could not stop students from referring to the textbooks or discussing answers with one another. The exam was organized in two parts: one made up of objective problems and the other consisting of partially subjective design questions. To prepare the objective part, a large library made up of approximately 100 problems was built, with each important piece of knowledge supported by four to five problems. Working with an algorithm developed by the online-teaching platform provider, a 50-point exam was created from the library that covered the entire syllabus but consisted of randomly selected problems.

Regarding the partially subjective part (worth another 50 points), I made my exam problem uniquely design oriented. For example, one teaching objective focuses on learning how to design a 180° hybrid rat-race ring [3]. Students were asked to write down the last two digits of their student identification number (i.e., ……*mn*), and they then were required to design, within a limited time, a planar hybrid ring operating at "$m + n$" GHz (there were no ……00 numbers) and show

the simulated *S*-parameters. The time period was controlled by the online tools. As a result, almost every student faced a different exam that was as fair as possible; even if two students ended up with the same question, they could not locate each other because they couldn't call everyone else taking the exam.

As a final note learned from practice, I would suggest that other professors planning to teach online not build their entire course based on a live webcast mode. In China, the school hours were the same for the majority of elementary schools, high schools, and universities, and the Internet service was unable to support such a huge volume of traffic; thus, the online tool often did not respond in real time. Instead, I suggest that instructors carefully determine which course content is suitable for screen-capturing video recording with narration and which is more suited for live speech, prepare the teaching resources accordingly, and upload them to the cloud before the scheduled lecture time. During the lecture time, use an audio instant messenger tool, such as Skype or QQ (saving bitstream bandwidth and enabling real-time presentation) to deliver one-way broadcasting to students or to organize discussions while receiving their feedback in text only. (QQ is a messenger capable of text, data, voice, and video developed by Tencent Inc. It is capable of storing text messages even when one is offline.) This is a much more doable approach. Cameras on both the instructor and students are not necessary because they distract people's attention. Sharing the instructor's computer screen with students is helpful since it allows instructors to explain their logic and deliver their lectures. As time goes on, instructors will become familiar with different webcasting tools and become a network anchor. Be advised: in the beginning of the semester, many students' family members will be attracted to the teaching sessions out of curiosity.

The key to attracting students' attention and keeping them focused is to discuss one topic within one video clip.

This was absolutely the worst and lowest time for everyone living in China as well as the best. It is bizarre to say that because there was not a day when we didn't miss being able to walk freely outside and talk to our friends without wearing masks. But, after receiving such incredible care and kindness from around the country and the world, I have a tremendous amount of optimism for the future. The virus evolved over many years before it could infect people, but humanity responded immediately. People demonstrated resolution as well as a sense of humor toward the disease. Children in grades one to three, for example, united on social media to give the online teaching products the lowest ratings possible because those tools "ruined" their playtime by bringing virtual teachers into their homes. Some say that the Earth sensed its existence was threatened by the human species and activated the virus to try to eliminate that threat [4]. But I say that Mother Nature is using the virus to reduce some of our sense of arrogance that we are the "owner" of the Earth and to give us a stronger sense of community and common cause.

At the time of the writing of this article, the "pause" button has been released in Wuhan. While our society is gradually getting back to normal, elite medical aid teams have departed to support other countries currently under attack by the virus. Students returning to classrooms is on the agenda, but that is a huge challenge because it involves 300 million people. The strategy? Starting with the remote, less densely populated provinces, high school students returned to school first because they faced the pressure of upcoming National University Entrance Exams (similar to the SAT in the United States) and most were local residents. College students were the last cohort to return to school because they live together in dormitories and 10 million of them needed to travel interprovince to return to school; such a massive movement of people carries a huge risk of spreading the virus. The Ministry of Education coordinated with the Ministry of Transportation and the Ministry of Public Health to come up with three hierarchical plans to guide students back to campus life. Some small businesses had a tough time, but not all of them had a sad ending. A private coffee shop in Wuhan, the owner of which committed to providing free coffee to health workers, miraculously survived through online virtual consumption; after his story was publicized, hundreds of people paid a small amount for a coffee without actually drinking it. The coffee shop staff loyally relayed the buyers' encouraging words by marking them on each cup. Tough times require tough people.

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