# On a Hybrid Delivery Approach to Science and Engineering Courses

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### Abstract:

A new hybrid delivery approach to science and engineering courses is proposed. The lecture and recitation parts of the courses are meeting half of the time remotely synchronous and half of the time face-to-face. The laboratory will be face-to-face only.

### Introduction:

New approaches on delivering courses were developed during the Coronavirus disease (COVID-19) pandemic [1]. A pandemic is an epidemic occurring on a scale that crosses international boundaries, affecting people on a worldwide scale. The delivery of lecture, recitation and the laboratory parts of a science and an engineering level course are challenging and become more so during the pandemic.

Two engineering level courses were partially delivered and are planned to be delivered on a hybrid approach [2]. The hybrid approach consists of remote and face-to-face delivery of the same course. The structure of the courses under consideration: Engineering Physics II – Electricity and Magnetism is Lecture (3 hours) – Recitation (1 hour) - Laboratory (3 hours), and Linear Electrical Systems and Circuit Theory for Engineers is Lecture (3 hours) – Recitation (1 hour) - Laboratory (4 hours); The laboratory includes one hour-lecture and three hours hands on practice. The lecture and recitation are combined and delivered two days a week on a two- hour meeting on one day and a two-hour meeting the other day. The lecture includes one or more demonstrations. The recitation includes detailed and structured solution of problems. The laboratory follows immediately after one of the combined lecture and recitation.

This proposal suggests the remote synchronous delivery of the part of the course that includes only half part of the lecture and half part of the recitation and the face-to-face delivery of the other half of the lecture part and the other half of the recitation part of the course. The laboratory is scheduled to coincide with one of the two days the course is face-to-face the course is delivered.

The lecture and recitation are combined and delivered two days a week on a two- hour remote meeting on one day and a two hour face-to-face meeting the other day. The lecture includes one or more demonstrations. The Zoom video conferencing platform [3] was mandated and used so the instructor can see everybody in the class and every student will see the instructor and the classmates. In the Fall 2021 the platform was changed to Blackboard Collaborate [4] because at this time the new version of the learning system was able to display up to twenty-five participants. Furthermore, Blackboard [5] was the learning management system (LMS) used offering better integration. This approach gave the feeling of the virtual classroom. The Laboratory follows immediately after the face-to-face meeting, and it is face-to-face itself.

During the Fall 2020 and Spring 2021 the laboratory was offered in a hybrid form [6]. The hybrid form included half of the laboratory experiments offered remotely and half face-to-face.

Discussions with the students took place many times on the preferable mode of delivery during the Corona Pandemic (Second half of Spring 2020 – Summer 2020 – Fall 2020 – Spring 2021 – Summer 2021 – Fall 2021) during which the courses were offered either totally remote for both lecture, recitation, and laboratory or remote for lecture and recitation, and hybrid for the Laboratory. For the Lecture and Recitation, the students replies can be summarized to "You present the topic and solve problems; we follow over the web and we have a dialogue (this dialog is a Socratic dialog) and asked questions. It does not make big difference the mode of delivery of this part of the course: remote or face-to-face." The hybrid laboratory consisted of alternating remote sessions and face-to-face Sessions. Students consistently agreed that the preferred format of the laboratory must be face-to-face.

## **Detailed Proposal:**

The proposed structure of two courses under consideration is described below along with details of the implementation. The courses follow a similar delivery in the lecture and recitation parts but differ in the implementation of the laboratory. One course has a 3-hour laboratory of measurements only (Physics II) while the other (Electric Circuits – first course) has a 4-hour laboratory spited is half remote and half face-to-face.

The Engineering Physics II (Electricity and Magnetism):

The courses (ENGR 2150/ENGR 2151 Engineering Physics II/Engineering Physics II Laboratory) consist of the Lecture (3 hours) – Recitation (1 hour) - Laboratory (3 hours). The Lecture and Recitation are combined and delivered two days a week: a two- hour remote meeting on one day and a two hour face-to-face meeting the other day, Figure 1. The examinations are taking place during the face-to-face meeting. The Lecture/Recitation part includes demonstrations. The equipment for both the remote and face -to-face demonstrations include standard components and instruments. For the remote part the instructor's home personal laboratory equipment as well as equipment he had borrowed from the school was used. For the face-to-face laboratory the school's equipment was used.

The Laboratory follows immediately after combined Lecture and Recitation. The laboratory meets after the face-to-face Lecture meeting is face-to-face. The laboratory is a one credit, three hours course. The face-to-face laboratory is used for the hands-on practical prototyping and measurements. The experimental results are proceeded and along with the theory are part of the Laboratory Report. Every Laboratory experiment is tight to the topic discussed in class. Every topic is covered in two meetings.

For three out the thirteen topics discussed (DC Electric Current, Resistance – DC Electric Circuits - AC Electric Current and Circuits) simulation was provided using a free, open-source electric circuit simulator [7].



Figure 1. Typical proposed structure of a course with lecture, recitation and one laboratory per week.

#### The Linear Systems and Electric Circuits for Engineers:

The course (ENGR 2620 / ENGR 2621 Linear Systems and Electric Circuits for Engineers/Electric Circuits laboratory) consists of the Lecture (3 hours) – Recitation (1 hour) -Laboratory (3 hours). The lecture and recitation are combined and delivered two days a week: a two- hour remote meeting on one day and a two hour face-to-face meeting the other day, Figure 2. The examinations are taking place during the face-to-face meeting. The laboratory follows immediately after both combined lecture and recitation in two-hour parts. The laboratory after the remote lecture meeting, is remote, while the laboratory after the face-to-face lecture and recitation meeting is face-to-face. The laboratory is two credits, four hours course. A laboratory experiment is split in two parts: the remote and face-to-face. The remote laboratory is used to analytically solve the problem under consideration in the experiment and then simulate it. The analytical and simulation results are discussed and must agree. The simulator used is the OrCAD Spice [8], a standard in the industry. The face-to-face laboratory part is used for the hands-onpractical-prototyping-measurements of the problem analyzed and simulated. The comparison of the analytical, simulation, and experimental results is a part of the laboratory report, and it is left as an exercise to the studious student.



Figure 2. Typical proposed structure of a course with lecture, recitation and one laboratory per week.

#### Some other Approaches:

Laboratory Kits: Various companies offered Laboratory kits for the General Physics and Engineering Physics. Although it is a nice attempt to offer something from nothing under the pandemic conditions, it is far from a replacement of the real Laboratory in school experiment, especially for the physics laboratory. The cost, the space, the nature of the equipment makes it impossible to delivered prepackaged experiments. Furthermore, the interaction among team members and the instructor are lost. The need of a technician to install, maintain, and service the equipment is irreplaceable. One of these sets of experiments was used in a General Physics class (Summer 2020). It is the opinion of this author that the experiments were too simplistic while other important topics totally missing.

<u>Simulations:</u> Laboratories are not simulations; simulations are part of an analysis process to verify and optimize the performance of a model of a physical system. Simulation has its own important place in the analysis and synthesis process but at the end the structure under consideration is build and measurements are made to verify the analytical and simulation results and to provide the performance characteristics of the real structure. The real structure, the physical structure, can never be modeled exactly and always a model approximates the real structure. The analytical exact solution is available for simple cases while computer numerical techniques are available today for problems without exact analytical solutions.

Simulation sites are widely available on the web written by people all over around the world. Some companies offered a simulation approach along with experiment kits. Although computer simulation has its value in the overall education it does not replaces the laboratory measurements. It is only part of the Analysis-Synthesis – Simulation – Measurement trilogy of the complete study of a phenomenon. Problems with either exact or non-exact analytical solution are necessarily simulated at first and them build and measured.

### **Conclusion:**

The hybrid delivery of a course for scientists and Engineers is a challenging proposition. It has been proposed the lecture and recitation to follow a hybrid (remote synchronous and face to face approach) while the laboratory to follow a face-to-face delivery. Discussion with the students supports this approach. It will reduce the in-college population to approximately half of the otherwise regular daily population. During the pandemic, this is a desirable proposition because it will greatly reduce the density of people in the various College areas. Unfortunately, the same cannot be said for the classroom and laboratory spaces where the suggested currently instructions must be followed. The reduction of the population density may reduce the transmission of virus.

The quality of education will stay the same, and the learning objectives of the courses can be obtained. The various technological meeting over the web tools provide a quality platform.

The environmental aspects of the hybrid approach must not be ignored. The patterns of either less transportation from home to school and back from school to home or from home will be eliminated, and from work to school and back to home will be eliminated or reduced contributed less pollution.

The saved transportation time can be used for study. During the face-to-face sessions it was reported by students that they spend half of an hour to an hour to commute from home or work to school. This makes one to two hours a day that can be used effectively studying, writing a laboratory report, preparing for an examination, or doing homework.

### **Further Work:**

Collection of data (examinations, course grades, student, and instructor comments) and comparison of traditional and the proposed structure will provide valuable performance and success conclusions.

### **References:**

[1] <u>https://www.who.int/emergencies/diseases/novel-coronavirus-2019</u> (Last Accessed: 4th of October 2021)

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[3] <u>https://zoom.us/</u> (Last Accessed: 4th of October 2021)

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