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Development of A Remote-Access, Simulator-Enabled, Team-Friendly Lab for an Electric Machines Course

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Abstract

In early March of 2020—as it became clear that our summer courses would likely be online and knowing that we lacked the means to offer an Electric Machines lab via such a modality—a literature search and a web search [1] - [4] were conducted to explore the available options. The findings of particular interest included a simulator that mimics the hardware/software in our physical lab [5] and a YouTube video describing a simulator that had been made asynchronously accessible to remote students via a Linux utility.

The appeal of the simulator we found is best conveyed by a summary of its capabilities. Students can use it to: place realistic "images" of equipment modules into a virtual workstation, add the necessary electrical connections, place a drive belt on machine pulleys, adjust instrument settings, take measurements using instruments having the same "look and feel" as the virtual instrumentation in our physical lab, and obtain results consistent with those of the actual equipment.

Unlike the remote-access application described in the YouTube video, we needed to create a team-oriented synchronous lab to enable provision of real-time instructor assistance and to broker the sharing of a relatively small number of simulator licenses among students in multiple sections of the course. Instances of the simulator were installed in virtual desktops hosted on campus to satisfy the simulator licensing requirements. A multi-user collaborative environment was selected to provide both a meeting environment for each section as a whole and private environments for the use of each team and the instructor. Means were also provided for teams to communicate with the instructor and for the instructor to visit a team's private environment either in response to a request for assistance or simply to check on the team's progress.

The remote-access, virtual lab thus described has provided an excellent means for distributed students to collaborate in a remote-teaching environment. The technical capabilities of its simulator have compared favorably to those of the physical lab it temporarily replaced. The on-call instructor assistance enabled by the collaboration software has been acceptable to students in terms of both extent and wait time. These conclusions are based on both instructor observations and an end-of-the-course student survey.

Overview

Context

The physical laboratory for our electric machines course uses workstations populated by modular Electromechanical System (EMS) equipment in the Festo LabVolt Series [6]. Although this system employs PC-based instrumentation, it is not suitable for unattended remote access. Festo also offers its Electromechanical Systems Simulation Software (LVSIM®-EMS) [7], which emulates the equipment in our workstations and serves as an ideal candidate for unattended remote access. Our objective—once this simulator had been located—was to use it to build a synchronous, team-oriented lab.

<u>Background</u>

Our first step on this quest was to specify what the system we were seeking would need to do:

A. Provide simultaneous access to a separate instance of a licensed simulator to each of 5-6 teams composed of 3-4 students and an instructor—each at a different off-campus location.

B. Enable each team to view a single instance of the software and pass control from one teammate to another throughout the session. If control-passing is not possible, provide—at a minimum—program control to a pre-chosen student per session with screen sharing by teammates and the instructor.

C. Provide sufficient video resolution during screen sharing (720p) to enable non-leader team members to clearly see the simulated equipment. Enable the instructor to monitor all team sessions simultaneously with the ability to full-screen a session at will. Provide a queued means for the instructor to receive team requests for assistance.

D. Provide team members with the ability to communicate with each other—and optionally the instructor—via voice or chat (at a minimum). Give instructor the ability to use video, voice, or chat to communicate with a particular team or the entire lab section.

E. Provide the instructor with an advance means to grant unattended-remote-access during a particular interval to each team-leader-of-the-week. If instructor-assigned scheduled-access is not available, give instructor the ability to terminate the session of any unauthorized user. If unattended remote access is not available, provide instructor the means to remotely grant requests for access at the start of each session. Minimize the administrative burden placed on the instructor to maximize his/her availability to monitor/assist individual teams.

Compromises were necessary on three of these objectives, especially Specification E.

<u>Execution</u>

1. Our initial application enabled teams to complete an exercise while the instructor circulated via Microsoft Teams to provide assistance or check progress without any co-location of participants.

2. The first lab of the semester was conducted as an instructor-led, class-wide demo shared via Microsoft Teams to introduce students to access details, screensharing considerations, and simulator operation.

3. Two-person teams were preferred to keep remote students engaged. Ten licenses were ultimately obtained—enabling support for twenty students per lab.

4. Teams were encouraged to have a rotating "lead teammate"—the name coined for the partner who controlled the simulator during a particular session.

5. At the start of the lab period, the lead teammate logs into VMware Horizon, uses it to access the LVSIM-EMS simulator, and then screenshares with teammates via Microsoft Teams.

6. Students were provided with two-page access instructions to enumerate steps required to gain simulator access—a process that required about a minute to complete once all steps were understood.

7. Instructor-written laboratory exercises were used, but a wide variety of exercises are included with simulator purchases.

8. Virtual labs were conducted by distributed students from June 2020 through April 2021. Virtual labs were completed by small teams of students sharing a computer in a common room on campus from June 2021 through November 2021. Some supplemental usage of the simulator is ongoing.

Remote-Access Software: *VMware Horizon Client* [8]

VMware Horizon can be configured to limit LVSIM-EMS access to enrolled students—via either a Windows or Mac client. The fact that the simulator is actually running in virtual desktops on a campus server simplifies administration while it complies with simulator licensing requirements. Use of the VMware Horizon Client is strongly preferred—as opposed to the use of "browser mode" access—since the latter does not support the multiple active windows that LVSIM-EMS needs to function properly.

Collaboration Software: *Microsoft Teams* [9]

<u>Initial Setup</u>

Students in each section were added to a specific team in Microsoft Teams (e.g., EE 3601-01). Lab teams were formed by adding subsets of these students to private channels (e.g., Team 1, etc. within EE 3601-01). Permissions were set so that only the instructor could add members to or delete members from a team or private channel. The instructor could easily add or delete students from teams and/or private channels as needed, even on a temporary basis.

An invitation to recurring Microsoft Teams meetings is sent to students early in the semester. Specific days—such as spring break or a *No Lab* week—can be deleted up front or as needed. Meeting reminders are available to students within Microsoft Outlook and schedules are available through the associated calendar.

Implementation

1. Any documents specific to a particular lab section can be posted in the *Files* section of that section's team.

2. A lab section starts in a common team and later separates into lab groups operating within private channels. The instructor can download an attendance spreadsheet from the common team at the start of the lab period and later complete an icon checkoff within each team's private channel shortly after large group dismissal—both for attendance purposes and to quickly assess whether any temporary team reassignments are needed due to absences.

3. Each team is expected to screenshare its simulator within Microsoft Teams [to enable instructor monitoring], even if support of separately located teammates isn't needed.

4. Teams use audio to communicate while observing simulator windows on their screens as the lead teammate completes the procedure. Other applications such as lab instructions can be shared within Microsoft Teams as needed.

5. Students can easily request instructor assistance while remaining in their team's private channel. When a student invites the instructor to join the team's private channel, an audio-assisted pop-up graphic presents the invitation to the instructor and identifies the requesting student; the instructor can *Accept* the invitation within a few seconds or add the student's name to a self-tallied queue to be processed in the order of receipt. Students can also post a help request in the chat associated with their team's private channel.

6. The instructor can easily visit each team in its private channel either by student request or instructor initiative.

7. The instructor can hover over "icons" within the private channels to determine whether a student is "presenting," "connected," or "on hold."

8. The instructor can send a chat message to a particular private channel or send a universal chat message that "penetrates" to all private channels.

9. Participant images—though available in most cases—were not used due to transmission overhead, prioritized workstation display sharing, and distraction/privacy concerns.

Extension

Private channels were sometimes used outside of the lab period for team meetings or virtual office hours with individual students or groups of students.

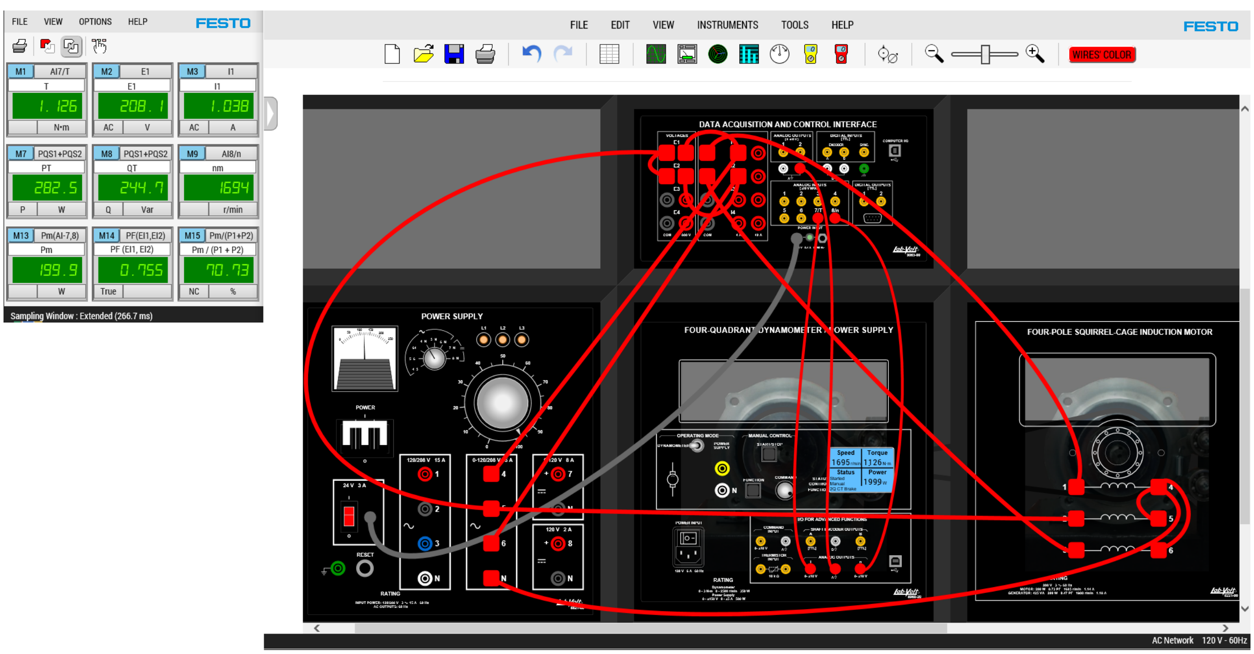
Simulation Software: *Festo LVSIM-EMS*

<u>Description</u>

Festo markets LVSIM-EMS as either a supplement to or a replacement for the corresponding physical equipment. Single-user, network, and vendor-hosted online options are available. We have a ten-user license for Version 4.24 of the network version.

The appearance and functionality of the simulator (see Figure 1) is very similar to the actual equipment. The setup in Figure 1 uses three full-height modules and one half-height module. Three additional full-height module bays—hidden by the zoom—are available on the top row of the workstation.

Not all of the specialized functions in the physical equipment have been implemented in the simulator, but all the functions needed by the Festo-supplied exercises are available, as are all the functions needed by the self-written exercises we use. The virtual instrumentation that accompanies the simulator appears to be functionally identical to the LVDAC-EMS virtual instrumentation we have on the benchtop PCs in our physical lab.



<u>Figure 1</u>: Module-Populated Workstation Accompanied by the Metering Window

According to Festo, "LVSIM-EMS simulates the electrical and mechanical characteristics of actual hardware modules, enabling students to perform experiments using virtual, interactive equipment that precisely reproduces the physical training systems." [10] Although a rigorous verification of this statement is beyond the scope of this paper, the results produced by the simulator have been very consistent with the results provided by the Electromechanical System equipment in our physical lab.

Distinctive Features

The simulator provides alternate means to verify connections and adjust knobs in a virtual lab while retaining functionality similar to that of the physical lab. It also facilitates the use of zoom and screenshots.

1. Cables can be shortened, color-coded, or oriented in a gravity-defying manner to improve their two-dimensional “presentation”—making it easier to check a circuit that has overlapping connections.

2. The *Highlight Nodes* function can be used to clearly identify all cables connected to a particular node. Given the circuit on the left side of Figure 2, a right-click on Transformer Terminal 14 followed by selection of the *Highlight Nodes* function changes the workstation appearance to that of the right side of Figure 2. This feature is very useful when verifying or troubleshooting a non-trivial circuit and serves a similar role to the user’s ability to lift and shift intertwined wires on a physical workstation.

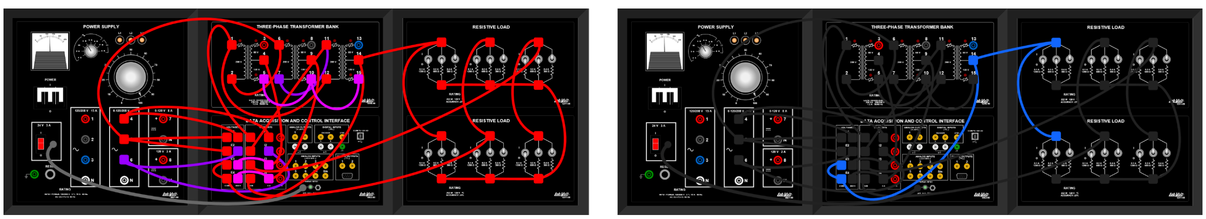


Figure 2: Workstation Row Without and With *Highlight Nodes* Function Engaged

3. The knobs on the simulator can be turned using a “super-radius” by clicking-and-holding on the knob and then dragging the pointer outward from the center of the knob to trace a path outside the knob graphic—not necessarily circular—while slowly manipulating the knob and affecting whatever adjustment the knob provides. This feature greatly simplifies efforts to achieve precise settings—especially when relatively small knobs such as the COMMAND knob on the 8960-20 dynamometer are involved (see lower-center of Figure 1). In our experience, this feature actually enables a control on the simulator to be set with more precision than is typically possible through actuation of the corresponding control in the physical lab.

4. The built-in zoom can be augmented through use of the web browser zoom—the latter being ideally-suited through usage of shortcut keys to take quick peeks at items such as ratings on faceplates before returning to the user-customized zoom setting within LVSIM-EMS.

5. Screenshots of measurement windows can be used to collect simultaneous readings from multiple instruments that have “noise”-dithering readings—either prior to recording values by other means or to serve as the actual documentation for the measurement. Unlike the preceding features in this section, this capability is also available when using the PC-based virtual instrumentation in the physical lab.

Attention-to-Detail, "Keeping-it-Real" Features

1. In the real world, a prime mover beside a generator is of no value unless the two machines are linked through mechanical means. The same statement applies to a motor that is adjacent to a dynamometer. In the physical lab, machine faceplates must be lowered to gain access to pulleys upon which a belt is to be placed. LVSIM-EMS requires a belt between machines before mechanical power can be transferred and it also requires the lowering of faceplates before a belt can be placed (see Figure 3).

Figure 3: Motor-Dynamometer Pairs with Faceplates Closed and Open

2. Good practice in the physical lab is to remove power before modifying electrical connections and to wait until equipment is stationary before lowering its faceplate. LVSIM-EMS users who violate either practice will receive a pop-up notice that specifically identifies how their behavior differed from safe practice.

Difficulties/Challenges

The most frequent problem we encountered was sporadic server overload—a product of our installation environment (and budget constraints)—not the capabilities of the LVSIM-EMS/VMware/Teams combination. The system response was slow at times due to the presence of resource-intensive programs such as CAD programs running on the same server.

A severe, yet infrequent problem we encountered was simulator access denials due to license exhaustion—despite the steps we had taken to avoid it. When invoked, LVSIM-EMS opens in licensed mode if a license is available. When all licenses are in use, LVSIM-EMS opens in demo mode. In our implementation, LVSIM-EMS was shared by students in four lab sections scheduled within distinct intervals. While we were unable to schedule-restrict student access to the simulator, the establishment of honor-system blackout intervals was reasonably successful at preserving simulators for team use during their lab periods. Access was honor system limited to one student per team, but some students failed to read, hear, or follow these instructions—causing grief early in the semester.

The honor system of sharing a relatively small number licenses is not entirely effective. To mitigate the impact of the license exhaustion problem, each lead teammate would attempt to gain licensed access to the simulator at the start of the lab period. In the event a license was unavailable, the instructor would temporarily redistribute members of the affected team among other teams who had already gained licensed access to LVSIM-EMS. Such redistribution was rarely required.

Most difficulties are believed to have resulted from limitations associated with our operating environment or student failures to follow instructions, not deficiencies in a particular software product. Had we, however, known in advance about all the challenges we would encounter, we would have still used the same simulator—and probably the same remote-access and collaboration software. There were a lot of excellent lab experiences interspersed among the difficulties we encountered.

Lessons Learned

1. Strategic layout of modules within the workstation footprint to minimize the working area can greatly improve the usability of the shared screen on smaller displays (see Figure 4).

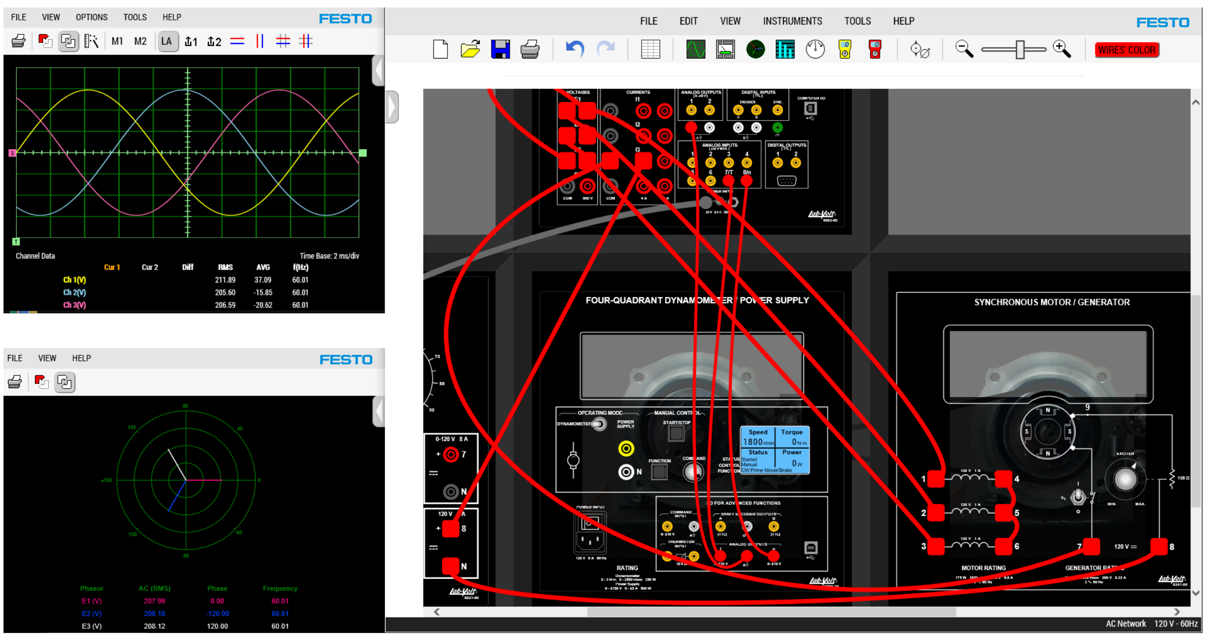


Figure 4: Optional Zoom to Enhance Work Area Viewability During Procedure

2. Utilization of dual-monitor capabilities enables the screen being shared to be dedicated to the simulator, but not all participants had the hardware available to support this approach.

3. Mac users faced challenges that Windows users did not, such as the need for double-tapping to access functions available through right-clicking on a Windows machine.

4. Usage of some form of scheduled, student-specific access control instead of the honor system would have been a preferrable approach.

LVSIM-EMS has served as a critical component of our remote laboratory. Looking forward, we may use it in support of an online electric machines course. A less obvious application is to use it as an ongoing supplement for the equipment in our physical lab. The availability of a good simulator enables consideration of some very useful exercises for which potential equipment damage argues against student completion with physical equipment.

It is worth noting that while many of our students have openly stated their preference to use "real" equipment to complete their lab exercises, many of them do recognize that the experience the simulator provided for them was comparable to a "real lab" in many respects.

Assessment

The effectiveness of the team-oriented, instructor-assisted, remote-access lab thus described has been substantiated in several ways. First, as the labs were being administered, the instructor observed student successes as they shared their results and demonstrated completion of the procedure. Second, the work students submitted was recognized to be comparable to the work received from students who completed similar exercises in our physical lab. Third, unsolicited feedback has been received from students who described their experience in a positive manner. Fourth, the instructor conducted and reviewed the results of the Virtual Lab Experience survey that is described below.

A student survey was conducted at the end of the Spring 2021 semester to gauge interest in alternative approaches, evaluate satisfaction with the instructor assistance that was provided, collect assessments of teaming methodology effectiveness, and obtain an overall evaluation of the virtual laboratory the students used. Seven Likert-scale questions and three essay questions were employed.

The Likert-scale questions are provided in Figure 5. A five-point scale ascending from *1-Strongly disagree* to *5-Strongly agree* was used to construct the possible responses. Questions 1-3 were originally phrased so negative responses favored the technique we used, while Questions 4-6 and 10 were phrased so positive responses favored this system. This tactic was intentionally employed in an effort to improve the validity of the results. Questions 1-3 as presented in Figure 5 have been oppositely phrased and their associated responses have been inverted (1 for 5 and 2 for 4) to enable the tabular summary in Figure 6 and the graphical summary in Figure 7 to offer a uniform "positive responses favor the implemented approach" perspective to simplify review. The original wording of Questions 1-3 is provided in Figure 8 for reference.

<u>Alternate Approaches</u>

1. I preferred working with a lab partner while using LVSIM-EMS instead of recording measurements while watching a pre-recorded video of the procedure being performed.

2. I preferred working with a lab partner while using LVSIM-EMS instead of running pre-written MATLAB scripts to obtain numerical results.

3. I preferred a synchronous lab with on-call instructor assistance over completing an asynchronous lab without real-time assistance.

<u>Assistance</u>

4. LVSIM-EMS shared within Microsoft Teams provided an effective means for our team to seek instructor help with issues such as equipment connections and instrument settings.

5. All factors considered, the typical wait time between requesting and receiving instructor assistance via Microsoft Teams was reasonable.

Teaming
6. The private team "space" we accessed in Microsoft Teams provided an excellent environment for my partner(s) and I to function as a team despite our differing physical locations.
Overall Evaluation
10. A synchronous Electric Machines lab accessed via VMware Horizon, powered by LVSIM-EMS, and shared within Microsoft Teams presents an attractive remote lab environment for self-isolating or commuting students.

Figure 5: Survey Questions with Likert Scale Responses

Statement	Response					Statistics			
	1	2	3	4	5	Total	Mean	Std	P-value
1	3	3	1	10	12	29	3.86	1.356	0.08077
2	2	0	4	6	17	29	4.24	1.154	0.00088
3	3	8	2	6	9	28	3.36	1.471	—
4	0	0	1	13	14	28	4.46	0.576	0.00000
5	0	0	1	10	17	28	4.57	0.573	0.00000
6	0	0	1	11	16	28	4.54	0.576	0.00000
10	0	1	4	9	13	27	4.26	0.859	0.00005

Figure 6: Survey Responses and Statistics

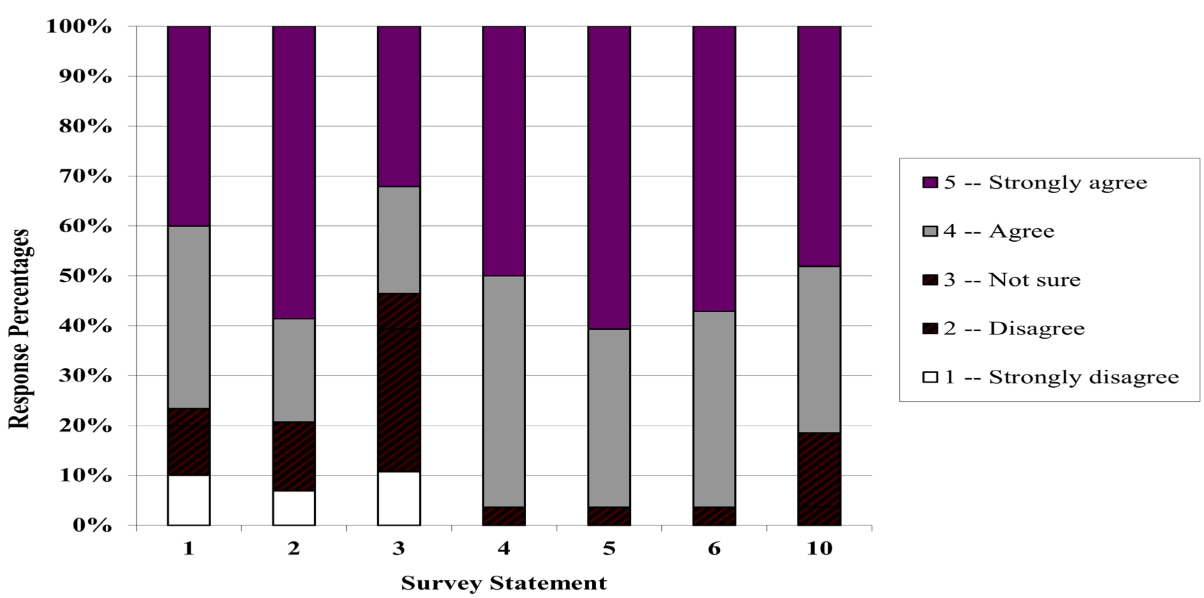


Figure 7: Response Percentages by Survey Statement

Alternate Approaches

1. Rather than working with a lab partner while using LVSIM-EMS, I would have preferred to record measurements while watching a pre-recorded video of the procedure being performed.

2. Rather than working with a lab partner while using LVSIM-EMS, I would have preferred to run pre-written MATLAB scripts to obtain numerical results.

3. I would have preferred an asynchronous lab without real-time assistance to a synchronous lab with on-call instructor assistance.

Figure 8: Actual Questions 1-3 Used in the Survey (See Text)

After defining a mean response of 3.5 or higher as a "tendency toward agreement," the t-distribution was used to compute—for each question—the P-value associated with the hypothesis that *the population mean of the responses to a particular question exceeds 3.5*. The P-values in Figure 6 indicate that students tended to agree with Questions 2, 4-6, and 10. Responses to Question 1 were somewhat mixed, with a sizable minority indicating they would have preferred the use of pre-recorded videos. The responses on Question 3 were split, with 54% of responses indicating some level of agreement and 39% of responses indicating some level of disagreement. An illuminating comment provided by a student in the essay portion of the survey acknowledged an initial attraction to the concept of asynchronous labs but expressed doubt that such labs would truly have been a better approach to the team-oriented, instructor-assisted labs.

The essay questions used in the student survey are provided in Figures 9-11. In the interest of brevity, only one-third of the responses to this portion of the survey [from a single section of the course] are being presented here. Comments that were vague, off-topic, or marginally relevant have been omitted. Comments chosen to be presented in the students' own words are included in Figures 9-11.

Question 7: *What—if anything—did you especially like about the EE 3601 virtual lab experience?* "I liked putting the modules together and making the connections...it was efficient for us to collaborate together to make the connections." "If the lab is going to continue online I believe the system in place is probably the best the lab can be. I think it makes you feel like you are in a physical lab..." "I really liked that the experience still seemed hands on while being virtual and safe. It worked really well for mimicking the in lab experience." "This was one of my favorite lab experiences. While being forced to comply with COVID restrictions, this Electric Machines lab still allowed us an environment where students can interact with virtual equipment to understand it's function and behavior." "I really like that the simulation modeled the setup we would have had in person so well. I have seen the equipment that is used for the in person lab and the corresponding simulation we used for lab contained all of the elements that are key to doing the in person lab almost exactly. I thought it was super cool that we had the opportunity to use the simulation and get probably the closest thing to the in person experience possible. I thought the simulation software was really quite smooth considering everyone was logged on at the same time and we were all using virtual machines to access the software." "I liked that the experience was similar enough to the real life lab, that I would feel comfortable handling these procedures in a real lab as if I had already done it before. So I don't feel like I lost an opportunity to practice with the real machines." "Personally I find that the main benefit of doing labs is that it teaches students about practical issues that you wouldn't otherwise consider when learning about the theory; like how to use measurement equipment properly, set up test equipment so that you can take accurate measurements. I also find that the lab experience helps students form a method of troubleshooting that can be invaluable. Although simulation wouldn't be my first choice I think that LVSIM provided a much better environment to build on these skills than MATLAB or LTSPICE simulations."

Figure 9: Selected Responses to Essay Question 7

Additional Question 7 responses ("likes") included: the simulator's ease of use, the virtual environment's zero chance of personal danger or equipment damage, the instructor's recommendation that teams employ rotating lead teammates, and the completeness of the instructor-prepared lab instructions.

Question 8: *What—if anything—did you especially dislike about the EE 3601 virtual lab experience?*

"The online labs do not help drive home the key relationships targeted as well as using the machines in person"

"The only thing that I disliked was the fact that it took so long to get started doing the labs, but this is not really [the professor's] fault, and I do not think it was any particular students fault either. People are always going to have issues using/communicating online, but that is just the reality of the situation. I do think there were probably some people who were straight up lazy and did not follow the step by step process that [the professor] had outlined on how to log on to and how to log off of the simulation. If I had to guess, this would probably be the biggest issue the class as a whole faced."

"I wish it could have been a physical lab..."

"Using virtual lab was not ideal. I understand there's probably not a better option..."

Figure 10: Selected Responses to Essay Question 8

Additional Question 8 responses ("dislikes") included: delays waiting for teams to verify licensed access to the simulator before starting the lab, difficulties when mistakenly accessing VMware Horizon via a web browser, and the absence of an asynchronous lab option.

Question 9: *What changes do you suggest we make to improve the EE 3601 virtual lab experience?*

"...out of the online options available this is as close to ideal as possible. If you have a recording some students will zone out and just click to the answers because they aren't as engaged in the activity. MATLAB is a great tool but EEs don't take a MATLAB class so students will have a wide range of skill using it. What might take one student 10 minutes might take another student multiple hours. The asynchronous lab idea sounded great when I first read the sentence but after thinking about it [, I think it would be problematic.] This semester I have had a lot of group projects and...a common theme is that a lot of students wait until the latest possible time to complete assignments. This would lead to LVSIM not being used a majority of the time and then a group of people all trying to complete the lab at the deadline...I really think the way the lab is ran now is pretty good."

Figure 11: Selected Response to Essay Question 9

Additional Question 9 responses ("improvement suggestions") mainly echoed responses obtained in Questions 7 and 8.

Conclusion

The LVSIM-EMS / Microsoft Teams / VMware Horizon combination has served us very well, enabling teams who would otherwise have been unable to complete "real" laboratory exercises to do so.

Acknowledgments

1. Were it not for the timely assistance of the Kennesaw State University UITS [University Information Technology Services] personnel to identify suitable/readily-available remote-access and collaboration software during the simulator acquisition phase of this project, it would have died in its infancy.

2. Permission to use screenshots of LVSIM-EMS in this paper was granted by Festo Didactic, Ltd.

References

[1] V. Yedidi, B. Johnson, J. Law, and H. Hess, "Creating Power Engineering Laboratory Experiences for Distance Education Students," *2005 ASEE Annual Conference*
[2] R. Belu, "Virtual Laboratory for Study of the Electric Machines Parameters and Characteristics," *2010 ASEE Annual Conference*
[3] R. Belu and I. Husanu, "Using a Virtual Platform for Teaching Electrical Machines and Power Systems Courses," *2013 ASEE Annual Conference*
[4] C. Spezia and G. Crosby, "BYOE: The Design and Operation of an Electric Motors Simulator," *2017 ASEE Annual Conference*
[5] S. Cumming, "Festo LabVolt LVSIM EMS Software Test Success 20 user license for CQU," [Online]. Available: www.youtube.com/watch?v=vQHvoS75rTM. [Accessed Mar. 28, 2022]
[6] "Electromechanical Training System Datasheet," Festo LabVolt Series, [Online]. Available: labvolt.festo.com/downloads/datasheet_579308(59-8010-90)_en_120V_60Hz.pdf. [Accessed Mar. 28, 2022]
[7] "Electromechanical Systems Simulation Software (LVSIM®-EMS) Datasheet," Festo LabVolt Series, [Online]. Available: labvolt.festo.com/downloads/datasheet_593356(98-8970)_en.pdf. [Accessed Mar. 28, 2022]
[8] VMware Horizon Client documentation, [Online]. Available: docs.vmware.com/en/VMware-Horizon-Client/index.html. [Accessed Mar. 28, 2022]
[9] Microsoft Teams documentation, [Online]. Available: www.microsoft.com/en-us/microsoft-teams/screen-sharing. [Accessed Mar. 28, 2022]
[10] Festo Electric Power Technology Training Systems brochure, p11 [Online]. Available: www.festo.com/net/en-us_us/SupportPortal/Downloads/649093/711502/DID1232/EMS/Classic/-/product/brochure/EN/(A4)/202104/(screen).pdf [Accessed Mar. 28, 2022]
[11] "Security Device Troubleshooting Resources," Festo LabVolt Series, [Online]. Available: labvolt.festo.com/downloads/SecurityDeviceTroubleshooting.pdf. [Accessed Mar. 28, 2022]