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Engineering by Remote Online Learning During COVID-19

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Abstract

Living with the Covid-19 pandemic has been a challenge. The decision in March 2020 to flatten the curve and control the transmission of the SARS-CoV-2 virus by lockdown, forced educators across all levels to aggressively consider and evaluate alternate options. This included underutilized functions of their current Learning Management System [LMS] and other collaboration platforms for virtual classroom instruction. For engineering educators, the LMS is often a complement to in-person classroom instruction. Platform choices included, but were not limited to Canvas, Blackboard, Microsoft Teams and Google Classroom. The adaptation and integration of video conferencing software also became increasingly significant. Educators had to quickly overcome the learning curve and effectively utilize Google Meet, Zoom, Slack or Skype to enhance their classroom communication needs. The challenge is not only how to become proficient with these tools, but how use them for effective pedagogy. The chosen collaboration platform must be integrated as an effective teaching tool, without becoming an ineffective distraction. All this while course content was revamped for the transition to a fully online teaching modality. How do you satisfy the required learning outcomes, and still maintain effective academic rigor?

This paper will look at some of these questions. Studies in several STEM related disciplines have shown that it is possible for remote instruction to satisfy the required learning outcomes, while sustaining academic integrity [1]. Many issues affect how to realistically and efficiently engage students while teaching remotely. This paper will look at some of these remote learning challenges encountered at Engineering Technology program at Queensborough Community College [QCC] of the City University of New York [CUNY]. Presented here some of the techniques and strategies employed to overcome the difficulties of remote learning at a minority serving institution. Some of the challenges included how to engage learners with limited or inconsistent internet access, the strategies and decisions in using synchronous versus asynchronous delivery. Concerns include how instructors are able to teach at a high level and conduct quality laboratory experiments remotely. Instructors were also mindful of the social isolation of our students and the need to create a community remotely as we isolated physically. Changes to the assessment strategies also had to evolve, from the traditional multiple-choice exam to other effective methods.

Keywords

STEM, Remote Learning, Learning Management System [LMS], Synchronous, Asynchronous.

Introduction

The rapid transition from in person to online modality was a necessary and swift response to the global pandemic. For educator accustomed to in-person learning the switch was jarring. A rapid transition offered little time to thoroughly prepare for such a move. Educators, accustomed to in-person classroom realize they have not had much training or experience operating in a remote, on-line modality. How do you ask questions, engage students, administer exam and conduct experiments? Internet access can be uneven, more than 40% of low income communities do not have high speed internet access at home [2]. For some students their primary internet access modality is "mobile-only" Internet. This describes student who have internet access only through a smartphone, tablet or other IEEE 802.11 [Wi-Fi] capable device [3]. These hardware devices however have limitations. They are sometimes restricted in their capability to run engineering computationally intensive applications. How do you manage the lack of hardware and the insufficient bandwidth? These and other issues are addressed below.

Hardware and Internet Access

Remote learning immediately highlighted the sharp incongruence with students' access to computer hardware and reliable internet access [4]. To conduct experiments remotely, faculty and students needed access to the required computer software, and the hardware to support them. Faculty may have cutting edge computer systems and hardware in their offices and in the laboratory. However, this was not the case at home. Faculty required a camera, microphone and laptop to support their computational needs. Year over year decline in PC sales translated to limited availability during the pandemic driven purchases. A software licensing plan also had to be formulated quickly to allow access to the required software while working remotely. Laptops, Chromebook and Wi-Fi modems were now a necessity for students who before have access to these tools on campus but not so while attending remotely. Software installation and licensing also have to be supported by the technical support staff. The synthesis of PowerPoint presentations with the LMS "whiteboard capability" provided an excellent method to engage visual learners. The ability to annotate circuit diagrams and solve equations worked well for active learning. These comprised a growing minimum set of hardware required for effective remote pedagogy.

Laboratories experiments present a challenge in an online environment. Students have no access to specialized test equipment found on a laboratory test bench. To accommodate

students' instructors often choose one of two deliverable models. Record and demonstrate key aspects of the required experiments so that students could the replicate or build upon via simulation remotely at home. Alternative would be to introduce or demonstrate the experiment live in a Synchronous mode. These session could also be recorded for Asynchronous presentation to those who were unable to attend in real time. Most instructors would end up choosing one or the other depending on what works best for the topics being covered.

Synchronous vs Asynchronous

Synchronous instruction offers the instructors and her class the option to meet at the same time and interact for real time learning. Instructors and student interaction in a live setting, offers several advantages. Synchronous presentation reduces the sense of isolation for students. Consistent weekly class meeting and collaboration recreate a learning community. The real-time interaction between instructors, students and their peers reduce the seclusion. Virtually immediately feedback and exchanges between students and instructors diminish the opportunity for miscommunication or misunderstanding. However, the synchronous commitment for class meeting at a specific day and time translates to a less flexible and less accommodating virtual classroom. Nonetheless, several LMS and collaboration platform offer the ability to record, and time shift the lecture presentation. Students are given the flexibility to join the class in real time or view the recorded presentation at their convenience later. The ability to time shift the lectures is an attractive option for students with limited internet bandwidth.

Asynchronous classes offers more flexibility in time. Learning engagements are accessible to students at a time of their choosing. Asynchronous instructors prepare, and upload their classwork material. Students can then assess the material at their convenience. Most LMS also allow students access to class materials and lectures from past classes. Student can typically progress at their own pace through the material independently. Students have the flexibility of engaging when they are able. This extra level of flexibility translates to increased intellectual engagement since student have more time to absorb and study the course material. However, these can be an increased sense of isolation and less of a community feel to the classroom. Research shows that some students learning outcomes improve when presented with a shorter, pre-recorded asynchronous lectures that they could assess when ready [5]. This would be a preferred option for students who lack reliable internet at home and struggled to access the synchronous lectures.

Performing experiments

Supporting students' experiments remotely during the pandemic was a unique challenge. Experiments are a critical and indispensable component for active learners in the Science Technology Engineering and Mathematics [STEM] fields [6] [7]. Laboratory experiments reinforce the theoretical concepts presented in the lecture. Hands on experiments provides

student an opportunity to become familiar with the test equipment on the laboratory bench. These are often similar to equipment seen in industrial laboratory. Circuits, networks and tests often do not work correctly on the first attempt. A student's ability to conduct experiments, analyze and interpret data, function on multi-disciplinary teams are skills often developed in lab classes. The ability to identify, and formulate solutions to engineering problems is also a program requirement by most engineering accreditation agencies. These are program accreditation criteria and requirement for accreditation agencies such as the Accreditation Board for Engineering and Technology [ABET].

There may exist undergraduate engineering students doing development, and undergraduate research. However the primary role of undergraduate laboratories is to satisfy educational objectives. For Undergraduate STEM students, the laboratory exercises reinforce and elucidate concepts presented in lecture. This can be accomplished using a suite of remote learning tools and simulations fit into this remote learning model. The use of software simulation tools is utilized in a variety of industries and application. Flight Simulation software reduce the cost of training pilots and astronauts. Military combat simulation prepare the military for lethal action, to improve marksmanship, and for weapons qualification. Simulation Program with IC Emphasis [SPICE] circuit simulation allowed students to opportunity to build circuits and conduct virtual experiment virtually. Virtual simulation can never completely replace the in-person experience, however virtual experiments does add value. Students can conduct the experiments is the privacy of their homes without the need to travel to campus. A wide variety of available software tools, serve the wide cross section of engineering needs. These include circuit simulation software for electronics, control systems, and simulation software for computer networks. Vendors offer cloud-based software as a service [SaaS] Integrated Development Environments [IDE]. Computer network simulation software can be used to simulate network traffic patterns, network security protocols, and both wired and wireless computer network functionality.

The pre-pandemic typical hardware deployment model consists of student personal computer laptop with the necessary software tools installed. Students conduct their experiments, develop their code, or simulated their network assignments utilizing the software deployed on their personal PC. Once the assignment is completed it is uploaded to the LMS for grading. Student face the upfront cost of minimum hardware required to support the required software.

A cloud-based IT deployment model offer greater flexibility and a viable solution for software needs during the pandemic. In this delivery model, students access a cloud-based SaaS platform via a web browser. System administration remotely managed by a cloud-based SaaS provider, and a multi-tiered cost structure makes this solution a competitive alternative. The Client can use programs and software functionality from anywhere remotely via an Integration Development Environment [IDE] or web interface. Student hardware requirement are simplified

considerably. The existence of a cloud-based solution considerably reduces the hardware resources required. Processing power and storage requirement can be effectively managed using a Chromebook computer which is significantly more affordable option. However students developing on a cloud based platform are dependent on stable internet connectivity.

Academic Integrity

One perplexing question for all educators remain how can we maintain academic integrity while assessing the course learning outcomes? Low stakes incremental weekly quizzes provide students an indication of their performance. It allows student to be able to identify their weaknesses while taking a course and provides students an opportunity to adjust their performance before completing the course and a final grade. The traditional high stakes mid-term and final cumulative assessments are used by most as effective indicators of academic performance. These were able to be securely administered and the results could be trusted with a high level of confidence. The assessments occurring at a define time, and methods could be employed to restrict communication, and control access to notes and course material. If this assessment modality were no longer available, then the handwritten exams had to be reimagined and transitioned to an online examination mode. Is it possible to maintain academic integrity in this laissez-faire existence?

Students' propensity to bypass established examination protocol are constantly evolving. While there are several technical solutions that exist in this space, the cost, effectiveness and ease of integration must be considered. A technical solution to this challenge might include the use of camera during online exams, keystroke parent analysis, and the use of lockdown web Browser technology. However, no matter how well conceived their countermeasures are, these methods are often challenge on the grounds of their legality and the obvious privacy concerns. The effectiveness of these methods is also called into question since students have multiple methods available to communicate, and to access information on the internet. Online proctoring services also exist however there is an associated cost. Even here however student have found way to bypass protocol for proctored online exams [8]. This is a place for a technical resolution however this must coexist with an effort to engage a student own sense of ethical responsibility. A student's academic integrity is a close correlation with that student's personal integrity [9]. Academic integrity has to exist alongside a personal ethical sense of responsibility

One of the first steps in this process is for the instructor to define academic integrity. The framework for this definition includes the discussion that academic integrity implies that course work submitted for that individual student for credit is her own. It can be expanded to include data derived from experiment and the interpretation and conclusion of that data are these of the author. If work submitted make reference or draws from the image, idea or works of others, that then proper credit has to be given and that work has to be cited. There are several methods

by which student can receive help in an online assessment environment. These include plagiarism, using another person's words and ideas without their consent, and taking credit for them as if they one's your own. Collusion occurs when one or more students submits the work of the group as the work of the individual. If groups of students are working collaboratively on a common project that is allowed, collusion occurs outside of this context. The possession and use of prohibited notes, books and material during examination and impersonation. There are other methods of deception as well. These include impersonation, which is a concern in an online environment and contract cheating. These are examples of violation of the spirit of the academic integrity policies and may be helpful if these are discussed with the class, defined and presented to the students as such.

What are common mitigation strategies? Inside the LMS are integrated features and tools to assist the instructor to developing some strategies to mitigate some of the changes mentioned above. The type of question you ask during an assessment makes a difference. Question design will also play an important role. Questions can be designed to require a higher level of thinking. The question that can be answered by a quick "Google" search should be avoided or at the very least used sparingly. Questions that require an explanation, some analysis, and some evaluation should be used in the majority.

Limit the examination duration and the testing window. Ideally the time allocated for an exam should be "just enough time" for an adequately prepared student to complete the exam using the knowledge developed in class, and from doing assignments and projects. However, finding the right time to allocate might require feedback across a cross section of student. In the online environment where no monitoring option is available, the assumption that the assessment is "open book" by default. This "open book" policy should be announced to the class to level the playing field, since some student will hold themselves to a higher ethical standard and disadvantage themselves.

Utilize a test pool with a wide cross section of questions on the topics covered. The likelihood of multiple students taking the assessment is the same physical space must be considered. Even if students are required to stay socially distanced while indoor, some students might not heed that advice. Utilizing and expanding on your test pool by refinement and the frequent addition of questions ensures that student are effectively taking different versions of the same assessment. The level or difficulty can be controlled in the creation of the pool of questions. Limiting the exam to one question at a time, and limiting the back tracking will make it less likely for co-located student to see "the same exam".

Randomize the question presented. In developing a comprehensive exam the instructor will draw from questions across several of topics covered in lectures and chapters covered in the

textbook. By randomly presenting the question during the assessment, students on the LMS taking the same exam will be presented with different question at that instant in time. This strategy will also minimize the opportunity for co-located student to collaborate.

Expand the variety of questions used: Refrain from or limit the use of multiple choice and true or false questions as much as possible. These multiple-choice questions limit the engagement of student's high level thinking skills, are the most likely to be searchable online

Maintaining a sense of community

While working remotely, Zoom, Blackboard Collaborate, Teams and Google Classroom have become ubiquitous, and synonymous with online learning. However, students have been isolated physically and academically. As colleges make an effort to welcome student back onto campus, several factors are preventing the wholescale return to campus at pre-pandemic levels. There are still students attending remotely. The extended time away from the social setting due to the pandemic has shed a light on mental health concern associated with students increasing sense of isolation. How can the instructor remain connected with the class without?

Students feel less isolated in a remote class setting when they are seeing a faces instead of looking at a blank screen. However the instructor should keep in mind that not every student is comfortable with cameras on. Students may be uncomfortable sharing their home with the class for a variety of reasons. Students are babysitting a child or taking care of a parent, or afraid of being judged by what may be revealed in the background while in class. In addition, technically, video requires more bandwidth in an already saturated, bandwidth starved environment. To help students the instructor can reduce the sense of isolation.

Meeting synchronously is one of the options already discussed. However it is mentioned here as an option to consider in reducing the sense of isolation. Active participation from students can also be a valid option as well. This can be done by instructor asking for response from a wide cross section of student during class discussion and during question and answer sessions. Interpersonal interaction during live in person session allow for student to engage, encourage and motivate each other. Some student may struggle to stay focused and be motivated while learning remotely. The instructor can sometime use the LMS to receive an alert if an assignment is missing or late. This presents an opportunity for the instructor to interact with the student. Often an email or other contact from the instructor will have a significant impact on student motivation

Conclusions

In this paper we highlighted the need for a variety of approaches necessary to address remote leaning in in STEM disciplines at QCC, and discussed methods utilized to engage students with a

varied, diverse approach. Techniques used to conduct experiments remotely, ensure a fairly and balances method for assessment, and how to best utilize Synchronous and Asynchronous modalities were also presented. Attracting, and maintaining a more varied group of students will result in a more diverse group of Science and Engineering [S&E] professionals. In the long term the society at large will bear the benefits from an increase in STEM knowledge and participation.

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