2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32851

Innovative Use of Technologies to Teach Chemical Engineering Core Classes and Laboratories During the Covid-19 Pandemic at an HBCU

Dr. Rupak Dua, Hampton University

Dr. Rupak Dua graduated with a Ph.D. in 2014 in Biomedical Engineering with a specialization in Tissue Engineering and Biomaterials from Florida International University located in Miami, FL. Dr. Dua worked for two years as a Postdoctoral Fellow at the Institute of Orthopedic Research and Education housed in Texas Medical Center - the world's largest medical center - located in Houston, TX. Before joining Hampton University in the Department of Chemical Engineering within the School of Engineering & Technology, Dr. Dua worked as an Assistant Professor in the Department of Chemistry at Hampden-Sydney College, where he taught and supervised undergraduates on clinically translated research projects. He has been an active leader in promoting STEM fields and has chaired several scientific and ethics sessions at national conferences. His current research focuses on improving or finding solutions for the musculoskeletal system disorders that still exist clinically through biomimetics, chemical, and tissue engineering approaches. Dr. Dua's research has been funded by several organizations, including the National Science Foundation (NSF).

Innovative use of technologies to teach chemical engineering core classes and laboratories during the COVID-19 pandemic at an HBCU

Rupak Dua
Hampton University, Hampton, VA, USA

Abstract

Most chemical engineering core classes are best taught when students are exposed to a face-to-face learning/teaching environment. With the arrival of coronavirus disease 2019 (COVID-19), the whole education system and the setting were disrupted at Hampton University (HU). Traditional in-person face-to-face classes were forced to move to remote instructions to maintain a healthy and safe campus environment and minimize the spread of COVID-19 on campus and in the community. As an instructor teaching core courses and unit operations laboratory in the Department of Chemical Engineering, it was challenging to move completely virtual and deliver instructions remotely without affecting students' learning outcomes. However, with the appropriate modern technologies and adapting to the students' change and needs, online teaching can be done efficiently and can still have efficient learning outcomes. Various activities were introduced to make the online/virtual class environment engaging in developing technical and professional skills and inducing learning for students. Using the latest educational tools and online resources, formative assessments were conducted throughout the course in an effort to improve student learning and instructor teaching. In addition to that, innovative ways of technology were also used to evaluate student learning and understanding of the material for grading and reporting purposes. Many of the modern educational tools, including Blackboard Collaborate Ultra, Kahoot, linoit, surveys, polls, and chemical engineering processes' simulations and videos were introduced to make the synchronous sessions interactive. Likert-like surveys conducted were analyses to gauge the effectiveness of incorporation of technology during remote learning. This paper describes the innovative use of technologies to adapt to the COVID-19 pandemic in the Chemical Engineering Classes. It will also explain the strategies to assess the mode of delivery efficacy and how to change the course of teaching to adapt to the students' changing needs.

Keywords

COVID-19, digital technology, innovation, simulations, education

Introduction

Most of the chemical engineering lecture-based core classes, including chemical engineering calculations, transport and thermodynamics, and Unit Operations Laboratories, are best-taught face-to-face in person-environment. Personal attention to students is being paid to students, and they seem to be much more engaged and less distracted in in-person classes compared with their teaching online or remotely. Further, when on campus, students also get hands-on activities on laboratory scaled industrial equipment in their unit operation laboratories class, thus reinforcing the theoretical coursework through the medium of experimentation that they learned in their sophomore and upper-level chemical engineering lecture-based classes [1-3].

With the arrival of COVID-19, it was challenging to make virtual classes interactive and engaging in the same way as the in-person classes are. To combat the problem, the instructor employed many technological interventions in instructional teaching during these unprecedented times to make the virtual classes lively while still educating and imparting knowledge to students during the Fall 2020 semester. The intervention used here has already been individually tested in educational settings and has been found engaging in the courses elsewhere. However, this was the first attempt to introduce those interventions in the core courses taught in the Department of Chemical Engineering at Hampton University. To get timely feedback from the students, formative and summative assessments were also conducted to modify the teaching methods and enhance students' learning during the semester. Students were also evaluated on the learning performances and understanding of the materials for grading and reporting.

The instructor had to be very creative and find novel methods to drastically change the teaching style from in-person classes to a distance learning environment while keeping the students engaged virtually. Some of the technology and innovative tools that were employed in chemical engineering classes in the Fall 2020 semester include Blackboard Collaborate Ultra, Kahoot, linoit, surveys, polls, simulations for chemical engineering processes, educational videos. During the semester and at the end of the courses, summative and formative assessment were collected to gauge student interest in these platforms in these courses. This paper provides an overview of the innovative use of technologies employed by the instructor during COVID-19 in the Chemical Engineering Classes while teaching remotely.

Methods

Participant:

The participants in this study were 24 undergraduate students comprised of sophomores, juniors, and senior's classification who were enrolled in Chemical Engineering courses offered online at Hampton University. Student participation in the survey was not required by the instructor but was optional and completely anonymous for the students.

Class Delivery Mode:

The teaching of Chemical Engineering Calculations (CME 201- 4 credit), Chemical Engineering Thermodynamics (CME 307 - 4credit), and Unit Operation Laboratory (CME 411 - 2 credits) during COVID-19 was done entirely online, with Blackboard being the delivery vehicle for instructions. We made use of both synchronous and asynchronous learning methods while teaching remotely.

Technology Employed:

The course involved completing both independent (e.g. reading material, viewing online content, reflecting on information) asynchronously and dependent (e.g. online interactions with peers and instructor) through Blackboard Collaborate Ultra synchronously. The instructor incorporated freely available online educational tools and in-built blackboard tools to make his classes engaging and interactive.

Instructor employed below mentioned tools to the lecture-based courses CME 201 and CME 307:

1) **Blackboard Tools:** Blackboard has many inbuilt tools that can be utilized to conduct an assessment and facilitate lectures. The instructor incorporated many of its tools such as
    - Course tools: This tool was used to create both formative and summative assessments and evaluations. Through these tools, the instructor used scaffolding learning with graded feedback via quizzes and homework assignments, low staking grading opportunities throughout his courses. In an effort to assess prior knowledge and what learning has taken place throughout the course, pretest and post-test were conducted on the first day and the last day of the course for the lecture-based courses, respectively.

    - Blackboard Collaborate Ultra: All the synchronous sessions were done on the Blackboard Collaborate Ultra. It is a real-time video conferencing tool built-in Blackboard that lets you add files, share applications, and use a virtual whiteboard to interact with students. Further, Blackboard Collaborate Ultra provided the following features that instructor used to make his classes engaging.
        - Polls: Integrative polls in Collaborate Ultra is an excellent way of getting students engaged and involved in a discussion. They also helped instructor to gauge student understanding of a particular topic.
        - Chat Box: Chatbox available through a Blackboard conferencing tool allows the students to provide comments and answers to the questions. The chatting setting was done in such a way that every participant can send a message to everyone or have the ability to send a private message to the instructor.
        - Annotation on the PowerPoint slides: Annotation on the PowerPoint slides is another excellent feature when teaching through collaborate ultra. The pencil tool allows us to draw freehand on the slide, which is somewhat equivalent to the chalk and board teaching style. This feature helped solve problems and explain concepts where complex equations were required. The instructor can even allow the student participants to try out the problems by assigning them the presenter role. Since it's a live session, everyone can view what the other student is typing as they would have seen in an in-person class.

    - Discussion Boards: The discussion boards allowed students to interact with other students and with the instructor actively. Every week, the instructor posted a question in the discussion board on the Blackboard for CME 201 and CME 307 class, where the student has to reply to the original question and provide two replies to the other students promptly. They were graded assignments and fostered critical thinking and were forced to think out of the box through these discussion posts.

2) **Surveys:** The instructor employed a web-based service Surveymonkey.com to conduct a

post-course survey at the end of the courses. Student feedback was collected using a questionnaire with a 5-point Likert-type scale made on surveymonley.com. The questionnaire consisted of seven questions for the lecture-based courses CME 201 and CME 307. Questions 1 was related to the overall satisfaction with the online learning experience in the class. Question 2 was about the easiness and clarity of the overall layout on the blackboard and course content. Question 3 relates to the use of technology incorporation in the class. Question 4 was about the incorporation of recordings and lectures in the classes. Question 5 relates to their satisfaction with the use of document camera in the class. Question 6 was related to providing regular feedback through surveys or minute assignments through linoit. Questions 7 relates to the satisfaction of observing the improvement in the method of delivery of instructions during the course. The responses helped instructor to evaluate the teaching approach's efficacy and the use of technology employed while teaching. Thus, this survey provided the summative assessments, and the feedback obtained will be used to modify the teaching approach for the future offering of online courses

3) **Kahoot:** Kahoot is an online platform developed to engage students in a distance learning environment. It fosters learning in an interactive, engaging, and entertaining way while staying on track with the curriculum and instructing online [4, 5]. The instructor created graded quizzes in the form of games, and students used to complete with each other. Though no extra credits were given for the winner, it was still entertaining and provided students an opportunity to learn in a new interactive way during these unprecedented times.

4) **Linoit:** It is an educational tool freely available to create a canvas of online sticky notes [6]. It allows the students to write their comments or views anonymously on these sticky notes that would be visible to everyone in the class. The instructor frequently used this tool in his classes CME 201 and CME 307 to get formative assessments. Forms of formative assessment used by instructor in his classes using this platform were:

    - **Minute Paper**: To gauge student learning, instructor employed giving minute paper assignments at the end of class. In these assignments, a short prompt was given, where students jot down responses to questions like "What were the most important concepts you learned today?"[7, 8].
    - **Muddiest Point:** This assignment was also similar to the minute paper assignment and was conducted using the linoit platform to determine which areas students were having trouble with and what approach the instructor should teach them or modify his teaching accordingly. In this assignment, the students jot their responses to the questions like, " What was the muddiest point during today's lecture?"[9].
    - **SII – Strengths, Areas for Improvement and Insights**: To get feedback from students on which teaching methods help them, what improvements can be done, and any additional insights they have to enhance their learning experience. The instructor conducted this assessment after 3-4 weeks of the semester, still at a point where the instructor was able to make changes.

In brief, Linoit provided a means to improve student learning and or instructor teaching amicably and interactively. Students were just provided the active link by the instructor during their live synchronous session and were able to respond to any questions asked individually, which everyone was able to see anonymously. In addition to writing basic text, the sticky notes posted on the Linoit platform also allowed to alter the sticky note's fonts' size and color. The comments provided timely feedback to the instructor and helped the instructor to navigate the semesters by adjusting his teaching methods.

5) **Document Camera:** A document camera was also utilized by the instructor in CME 201 and CME 307 that provided the students the ability to see an object or text clearly in a virtual classroom, which is essential for comprehension and understanding of concepts.

6) **Recording of the class:** All the synchronous lectures were recorded using collaborate ultra-feature and were uploaded on Blackboard in a timely manner. These recordings provided an opportunity for students to watch the entire lecture in their own leisure time if they need to. It has been found that documentation via video helps retain the information, and instructional videos' provision increases student performance in the class [10, 11].

Technological tools applied for teaching unit operational laboratory (CME-411) virtually:

In addition to some of the technology applied to the unit operations laboratory, CME 411, including Blackboard and its tools, Kahoot, as mentioned for the lecture-based courses, instructor also incorporated chemical engineering processes simulations and educational videos in this particular course.

1) **Simulations:** In an attempt to provide hands-on like experience virtually for the chemical engineering processes, the interactive simulations for the chemical engineering processes were employed in this course. It has been found by other investigators that simulations also helped in improving students learning outcomes [12, 13]. The simulations used in the course CME 411 were provided through the Ministry of Human Resource Development (MHRD), Govt. of India, initiative and were open accessed [14]. The simulations employed stimulated real experimentation and allowed students to collect the data and analyzed it virtually in the same manner as what they would have done in person.

2) **Educational Videos** To enable a better understanding of the theoretical concepts and experimental designs of the chemical engineering process, educational videos through the Journal of Visualized Experiment (JOVE) and YouTube were also incorporated and watched during the unit operation laboratory synchronous session.

3) **Survey:** At the end of the course, the instructor also conducted a survey using a questionnaire with a 5-point Likert-type scale made on a surveymonley.com with just 5 questions. Technology relevant questions were only questions 2, 3, and 5. Question 2 was about the easiness and clarity of the overall layout on the blackboard and course content, same as for the lecture-based course, while question 3 relates to the students' satisfaction with the use of simulations in the virtual environment, and Question 5 deals with their satisfaction on the incorporation of educational videos presented in the class.

Results

The student sample consists of responses from 19 students from the three classes in the Department of Chemical Engineering at Hampton University. 17 responses of students out of 19 students were from the lecture-based courses. In contrast, 2 responses of students out of 5 students were from the Unit Operation Laboratory class. The participation rate for the survey that was conducted at the end of the semester to evaluate the teaching approach's efficacy and the use of technology employed was 89.5% for lecture-based courses (CME 201 and CME 307) and 40 % for unit operation laboratory (CME-411) respectively. The results of responses have been shown in Figure 1 for the lecture-based courses. We found that for lecture-based courses, the average pretest was 4.6 and increased to 8.3 in the post-test conducted at the end of the courses. For the Unit-Operation laboratory, we got mixed feedback. 50% of the students who responded agreed that the simulations in the virtual environment provided hands on like experience for laboratory scaled industrialized instruments while the other 50% strongly disagree. Similarly, 50% of the students who responded strongly agreed that the educational videos presented in the class helped improved their learning outcomes, while 50% strongly disagreed with that.

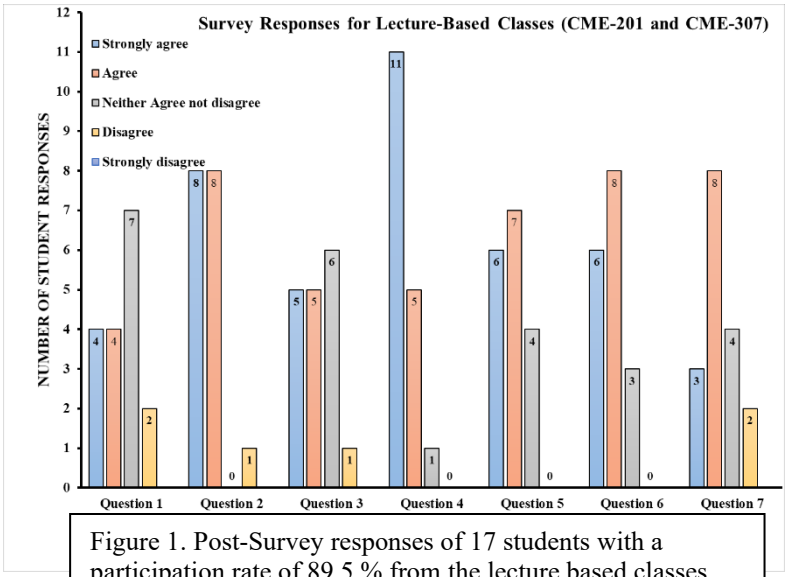

Figure 1. Post-Survey responses of 17 students with a participation rate of 89.5 % from the lecture based classes.

Discussion and conclusions

With the technological interventions in the courses, we found that the student learning outcomes and understanding was improved specifically for the lecture-based classes. Reflections obtained from the students during the survey also confirmed that. From the surveys for the lecture-based courses, we found that 16 of the 17 students who responded found the Blackboard layout and under course content developed by the instructor was straightforward and easy to follow. This won't be possible without the use of blackboard tools. Further, most of the students agreed that the technology incorporated in these courses (Kahoot, Linoit, polls) helped make the class engaging while only 1 student disagreed. All the students except one who didn't have any opinion on the recordings and lectures agreed (11 strongly agreed) that the recordings and lecture notes uploaded on the Blackboard provided for each class helped in their learning process. These survey reflections of improving students learning outcomes due to the intervention of technology into courses were further supported from the pretest and protest of the courses that was conducted. There was an increase of 80% score when comparing the pre and post-test average, thus improving the students' learning outcomes at the end of the semester. We argue that this was only possible because of the technological intervention that was placed in teaching these courses that helped to provide an education in a way that is understandable, fun and interactive

Besides, through technological intervention, we could conduct formative and summative assessments and evaluations in a very friendly manner. That further provided us the opportunity to change our teaching approach to improve student learning outcomes. For instance, through our SSI formative assessment that was conducted after 4 weeks of the semester, students provided feedback that they were having difficulties understanding the annotation when scribed over a PowerPoint slide in blackboard collaborate ultra that significantly has less white space. Moreover, the limitation on the touch screen makes it harder to write appropriately sometimes. Based on that crucial feedback, the instructor introduced the document camera to make the comprehension and understanding better. This was further supported by the student's feedback that was received at the end of the semester. Out of 17 students who responded to our question about introducing a document camera in the class helped them improve their learning outcomes, 6 of them responded strongly agreed, 7 agreed and 4 neither agree nor disagree. This clearly shows that a document camera is a beneficial educational tool.

In conclusion, the availability and the use of modern technology and educational tools can be a key to teach effectively and make learning possible in chemical engineering courses virtually, even during such an unprecedented time.

Acknowledgment

This work was supported by the National Science Foundation under Grant # 2000061.

Disclaimer

Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

References

[1] Zhang, M.J., C. Newton, J. Grove, M. Pritzker, and M. Ioannidis," Design and assessment of a hybrid chemical engineering laboratory course with the incorporation of student-centred experiential learning", *Education for Chemical Engineers* Vol. 30, 2020, pp. 1-8.

[2] Hofstein, A., and R. Mamlok-Naaman," The laboratory in science education: the state of the art", *Chemistry education research and practice* Vol. 8, No. 2, 2007, pp. 105-107.

[3] Russell, K.," Bridging Theory and Practice on a Budget: A model for delivering practical knowledge through partnership with an on-campus facility".

[4] Curto Prieto, M., L. Orcos Palma, P.J. Blázquez Tobías, and F.J.M. León," Student assessment of the use of Kahoot in the learning process of science and mathematics", *Education Sciences* Vol. 9, No. 1, 2019, pp. 55.

[5] Plump, C.M., and J. LaRosa," Using Kahoot! in the classroom to create engagement and active learning: A game-based technology solution for eLearning novices", *Management Teaching Review* Vol. 2, No. 2, 2017, pp. 151-158.

[6] Triyono, B., and A.F.R. Syafei," Using Lino. it application in teaching English", *Journal of English Language Teaching* Vol. 5, No. 1, 2016, pp. 137-145.

[7] Stead, D.R.," A review of the one-minute paper", *Active learning in higher education* Vol. 6, No. 2, 2005, pp. 118-131.

[8] Chizmar, J.F., and A.L. Ostrosky," The one-minute paper: Some empirical findings", *The Journal of Economic Education* Vol. 29, No. 1, 1998, pp. 3-10.
[9] Waters, C., S.J. Krause, J. Callahan, B. Dupen, M.B. Vollaro, and P. Weeks," Revealing student misconceptions and instructor blind spots with muddiest point formative feedback", 2016.
[10] Bristow, E.C., J.C. Bruhl, and J.L. Klosky," Effect of supplemental instructional videos on student performance in engineering mechanics class", *International Journal of Engineering Education* Vol. 30, No. 3, 2014, pp. 566-575.
[11] Abbitt, J., and B. Carroll, "Using Technology to Enhance Undergraduate Learning in Large Engineering Classes", *American Society for Engineering Education Annual Conference & Exposition, Atlanta, GA*, 2013.
[12] Borreguero, A.M., J.L. Valverde, J.M. García-Vargas, and L. Sánchez-Silva," Simulator-based learning in the teaching of chemical engineering", *Computer Applications in Engineering Education* Vol. 27, No. 5, 2019, pp. 1267-1276.
[13] Corter, J.E., S.K. Esche, C. Chassapis, J. Ma, and J.V. Nickerson," Process and learning outcomes from remotely-operated, simulated, and hands-on student laboratories", *Computers & Education* Vol. 57, No. 3, 2011, pp. 2054-2067.
[14] Dutta, S.J., and R. Bhattacharjee, "Integration of Virtual Laboratories: A Step Toward Enhancing E-learning Technology", *2019 IEEE 5th International Conference for Convergence in Technology (I2CT)*: IEEE, 2019, pp. 1-5.

Rupak Dua, Ph.D.

Dr. Rupak Dua is an Assistant Professor in the Department of Chemical Engineering within the School of Engineering & Technology at Hampton University. Dr. Dua's research focuses on improving or finding solutions for the musculoskeletal system disorders that still exist clinically through biomimetics, chemical, and tissue engineering approaches. Dr. Dua graduated from Sathyabama Institute of Science & Technology located in India with a Bachelor's in Biomedical Engineering and received his MS and Ph.D. in Biomedical Engineering from Florida International University. Dr. Dua teaches sophomores, junior and senior-level chemical engineering courses to engineering students. Dr. Dua's research has been funded by several organizations, including the National Science Foundation (NSF).