ChE COVID-19 special section

AICHE VIRTUAL COMMUNITIES OF PRACTICE – SUPPORTING FACULTY DURING THE COVID-19 PANDEMIC

Matthew W. Liberatore[1], Daniel Lepek[2], Laura P. Ford[3], Tracy Carter[4], Jennifer Pascal[5], Monica Lamm[6], Christi Patton Luks[7], David L. Silverstein[8], Ashlee N. Ford Versypt[9], Stephanie Butler Velegol[10], Troy Vogel[11], Neha Raikar[12], Matt J. Kipper[13], and Christy Wheeler West[14]

1. University of Toledo • Toledo, OH 43606
2. The Cooper Union • New York, NY 10011
3. University of Tulsa • Tulsa, OK 74104
4. Northeastern University • Boston, MA 02115
5. University of Connecticut • Storrs, CT 06269
6. Iowa State University • Ames, IA 50011
7. Missouri University of Science & Technology • Rolla, MO 65409
8. University of Kentucky • Paducah, KY 42001
9. University at Buffalo • Buffalo, NY 14260
10. Pennsylvania State University • State College, PA 16801
11. University of Notre Dame • Notre Dame, IN 46556
12. University of Maryland – Baltimore County • Baltimore, MD 21250
13. Colorado State University • Fort Collins, CO 80523
14. University of South Alabama • Mobile, AL 36688

INTRODUCTION

Lifelong learning is a skill needed by faculty, students, and practicing engineers. While state-of-the-art instruments are developed and quickly adopted in faculty's research labs to remain relevant, new teaching methods based upon documented evidence can be much slower to propagate.[1, 2] Experienced faculty may be aware of and interested in research-based teaching methods, but they may also have concerns about the time required to apply them, potential resistance from students, and not having a mentor to help navigate difficulties in adopting these methods. Due to the COVID-19 pandemic and related shutdowns and restrictions, many of these concerns were exacerbated, as faculty had to quickly change their teaching approaches to remote, online, and other hybrid formats. Thus, gaining a stronger, foundational understanding of research-based teaching methods, especially for online instruction, served as motivation to create these Virtual Communities of Practice.

Virtual Communities of Practice have served as a proven technique for enhancing the professional development of faculty. A community of practice is primarily a learning community — a group with an identity focused on a learning goal.[3] The term "virtual" is critical to the name, Virtual Community of Practice (VCP), as meetings are held via the Internet and video conferencing rather than in person. The effectiveness of VCPs for faculty development has been reported over more than 15 years.[4-14]

Notably, VCPs have guided faculty into adopting different, and often novel, teaching methods. In one study, twenty faculty members from ten universities participated in a semester-long experience with an orientation and weekly on-line discussions.[12] Each university was represented by one faculty member from engineering and one from science, math, or computer science. The program included readings and discussions of educational pedagogy, and each faculty member developed, implemented, and assessed a curriculum project. Since faculty were already predisposed to using

effective teaching methods, the program confirmed their use of evidence-based methods rather than influencing the adoption of new pedagogical methods. The participating faculty did provide evidence that they will continue to apply what they learned to other courses and that they experienced professional growth from participating in the program.

VCPs associated with chemical engineering, materials science, and biological engineering have been organized in the past, some under the auspices of ASEE.[13] From those VCPs faculty reported increases in the use of Bloom's Taxonomy, student learning objectives, active learning, and cooperative learning from before the VCP to after the VCP.[13] While many professional development activities are focused on tenure-track faculty (pre-tenure), programs that include diverse faculty perspectives will likely lead to better outcomes for a more diverse cross section of students.[15-17] Thus, the AIChE Education Division (Ed Div) developed a series of Virtual Communities of Practice open to all chemical engineering faculty members regardless of career phase, title, tenure status, or other classifications.

When classes shifted online in March 2020, chemical engineering faculty were abruptly forced to change their mode of instruction across all chemical engineering courses, which commonly include problem solving, projects, teams, and laboratories unique to our discipline. This paper will highlight the genesis of the AIChE Ed Div's VCP program, describe its impact on faculty members' professional development during the pandemic, showcase how best education practices were shared, summarize the topics discussed during the VCP meetings and, lastly, address how the program itself significantly impacted chemical engineering education during the COVID-19 pandemic.

MATERIALS AND METHODS

Creating a community begins with finding potential members and engaging them. With faculty quickly shifting to remote work in March 2020, an online survey (Google Forms®) was constructed by AIChE Education Division Leadership (Matthew Liberatore and Daniel Lepek) to gauge the interest of faculty members in forming virtual communities in order to discuss best practices for online and remote instruction. Questions included: name, email, courses being taught, willingness to host/lead a group, and a place for other comments and ideas. A second survey distributed in July/August of 2020 also asked for contact information and VCP preferences. In addition, survey questions were also included regarding previous participation in the earlier VCPs, start date of the fall term (as many universities shifted to earlier start dates), modes of fall instruction, and topics of interest.

Virtual meetings were hosted and organized by individual faculty leaders (the co-authors of this paper) using a web-based video conferencing platform such as Zoom® or WebEx®. Links and passcodes were shared via email based on the participation survey's responses. In addition, recordings of the web-based meetings, notes from the meetings, slides presented or created as parts of meetings, and course materials were shared with the members of each VCP via cloud-based file-sharing systems such as Google Drive® and Slack®.

To determine the impact of the AIChE Ed Div's VCP program on chemical engineering faculty members and their course offerings, a survey was designed to assess topics such as VCP participation, introduction to new pedagogical methods, mastery of new technology, and the development of an online faculty community. A link to the anonymous, online survey (distributed using Microsoft Forms® and with IRB approval) was sent to all VCP participants in July and December 2020. In both cases the surveys were left open for accepting responses for several weeks.

RESULTS AND DISCUSSION

The impacts of the AIChE Ed Div's VCP program on the delivery of chemical engineering courses during the COVID-19 pandemic were wide-ranging. A timeline summarizes key events described throughout this paper (Figure 1). First, the initiation and overall operation of five different VCPs will be presented. Next, VCP-level details and anecdotes captured based on the diversity of experiences found across the communities will be provided. Finally, results from surveys completed by participants about the impact of the VCPs on specific components of their teaching from March 2020 to December 2020 will be discussed.

Setup and Overall Organization of the VCP Program

With in-person classes being shut down at universities across the world in March 2020, chemical engineering faculty were abruptly forced to change their mode of instruction in just a few days. Since chemical engineering courses include problem solving, projects, teams, and laboratories, transitioning to online instruction could be quite different than other disciplines in higher education.[18]

To first help the chemical engineering community transition to online instruction, the AIChE Ed Div sponsored a one-hour webinar by Sarah Wilson and David Silverstein on teaching chemical engineering online, which occurred on March 20, 2020 as part of the ongoing webinar series of the AIChE Ed Div.[19] The live attendance at this webinar included over 130 participants, which is similar to the number of ABET-accredited chemical engineering programs in the United States. A poll question during the webinar found that over 70% of the attendees had never taught online. Finally, the recording was posted to YouTube® with hundreds of views being recorded in the weeks afterward and is archived in the AIChE Academy.[19]

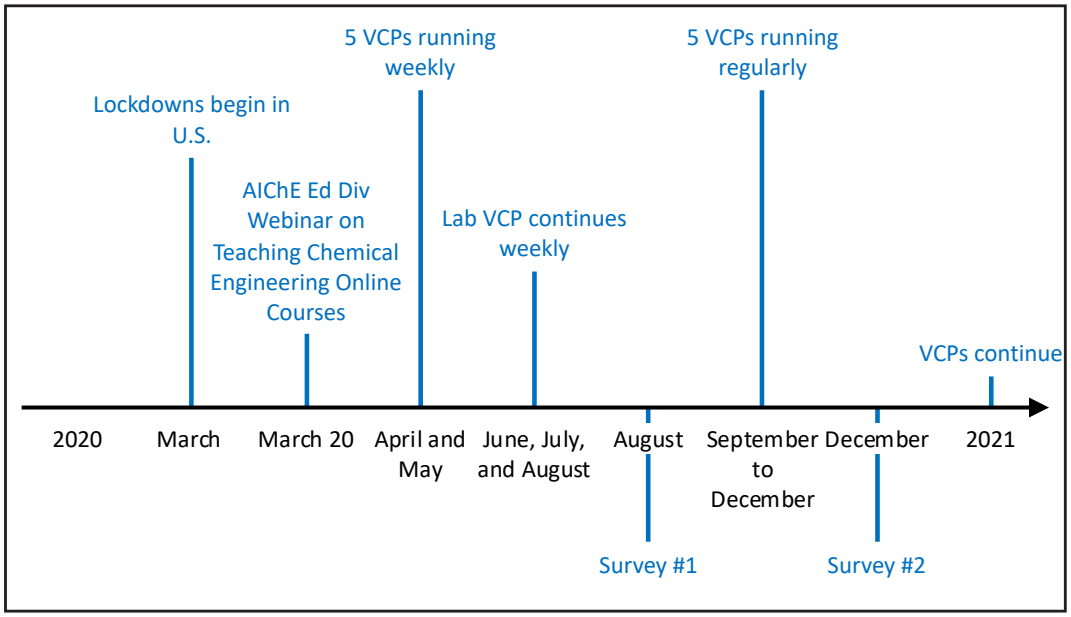

Figure 1. *Timeline of key events related to the formation and persistence of five chemical engineering virtual communities of practice.*

Next, a web-based interest form was circulated to attendees and other members of the AIChE community. Respondents were asked whether they would like to participate in a VCP, to identify course(s) they were teaching, and to indicate their willingness and ability to lead/moderate a VCP. The AIChE Ed Div asked individual and small groups of faculty to leverage their local institutional resources to help host online meetings via Zoom, WebEx, and other similar platforms. Volunteers and expertise hosting VCP meetings were not a limitation at any point. Daniel Lepek and Matthew Liberatore, both current and past chairs of the AIChE Ed Div at the time, orchestrated the setup and overall organization of the VCPs. Finally, the interest form concluded with an open-ended question asking for feedback or suggestions.

Within one week 88 faculty members filled out the form, and the communities began to materialize. The total number of interested participants continued to grow throughout the semester and into the following semester. From March 2020 to December 2020, 191 participants from 101 universities and from 9 different countries expressed interest in the program. While most participants were AIChE members (78%), less than half were members of the AIChE Ed Div, which exemplifies broader impact. Finally, regular attendance of the five VCPs varied greatly with over 80 faculty participating during the most active weeks. Information associated with the overall participation in the Virtual Communities of Practice is provided in Table 1.

Five VCPs based on course topics or groups were formed with at least two volunteer leaders for each VCP. Next, contact information of the interested participants was distributed to the leaders and meetings began. Since finding an agreeable weekly meeting time was the first action to start meeting regularly as a VCP, some leaders hosted informal coffee hours to talk about their courses, online resources, and support within their department or university. Once an agreeable meeting time was established among the participants, weekly VCP meetings began in late March or early April for all five VCPs and continued into May.

The frequency of the VCP meetings decreased in mid-to-late May as most faculty were completing their terms. While four of the five groups paused, the lab VCP continued meeting weekly throughout the summer. The structure and highlights from each of the five VCPs are included in subsequent sections.

Four VCP leader meetings occurred in March, May, July, and December 2020. First, the leaders reviewed the objectives of the VCP program, which were primarily to support faculty. Next, each VCP reported on their meeting logistics, frequency, structure, and other details discussed throughout this manuscript. The leaders also cataloged successes, challenges, and opportunities specific to their VCP, and many of these ideas are summarized in the next section. During these leader meetings, each leader provided anecdotes associated with their individual VCPs. Finally, plans for the next phases of the VCPs were discussed, as restrictions on in-person instruction continued throughout 2020 and into 2021.

More quantitatively, the leaders summarized their attendance and number of meetings (Table 2). Based on these data, a community formed and perpetuated if five or more faculty met regularly, and some communities remained attractive to

larger groups, which included lab and the early core courses of mass and energy balances and thermodynamics. With the framework established for the five VCPs, specifics on each community are detailed next.

Virtual Communities of Practice

Transport/Separations VCP (Facilitators: Lamm, Lepek, Velegol). The Transport/Separations VCP met throughout the Spring and Fall 2020 semesters to support instructors teaching courses on separations and transport phenomena, including fluid mechanics and heat and mass transfer. During the Spring 2020 semester, this VCP focused specifically on three immediate needs: technology resources, teaching strategies, and assessment plans. In terms of technology, some challenges that were observed include identifying ways to help students with graphical methods, such as McCabe-Thiele and Hunter-Nash, if access to printers was a challenge. Another challenge was figuring out ways to help students connect remotely to access process simulation software, such as Aspen HYSYS®. General concerns regarding internet access and reliable computers/smartphones, and their impact on synchronous versus asynchronous lectures, were also discussed. Some of the teaching strategies shared included using projects and online oral exams instead of in-class assignments and exams. Changes to assessment plans were a significant concern as instruction went online. Discussions regarding upholding academic integrity, assessing the impact of institutional grading policies, and identifying new methods of online assessment formed the basis for many meetings. For example, some participants used the AIChE Code of Ethics as a platform to reinforce concepts of academic integrity.[20]

The Fall 2020 VCP began by focusing on common challenges observed from instructors; these challenges included student engagement in remote learning environments, achieving academic integrity and equity with online assessment, and anticipating the online time commitment of students. Some strategies discussed to achieve academic integrity with assessments included assigning shorter quizzes focused on specific learning outcomes, following-up written exams with individual student meetings, and being proactive about explicitly explaining behaviors that violate course academic integrity policies. New topics that were discussed in this VCP included community building and connection, learning and metacognition, and diversity, equity, and inclusion. Participants shared strategies for promoting learning and engagement in their courses; examples included identifying stress relievers, encouraging and honoring mental health days without traditional fall or spring breaks, using apps such as Kahoot!®, and collecting plus/delta feedback.[21, 22] To promote a discussion on diversity, equity, and inclusion, participants shared articles on these topics, and the group reflected on how to incorporate these topics into their courses. At the end of the VCP, participants shared their successes (e.g. giving quizzes instead of exams, adding more hands-on demonstrations) and possible continuing challenges (e.g. teaching graphical methods online) while teaching transport and separation courses.

TABLE 1
Overall Participation in Virtual Communities of Practice

Total Unique Participants Signing Up for VCPs	191
Total Institutions Represented	101
Total Countries Represented	9
AIChE Members	78%
AIChE Education Division Members	44%
Regular Attendance during Spring/Summer 2020 VCPs – 5 VCPs in Aggregate	38-85
Regular Attendance during Fall 2020 VCPs – 5 VCPs in Aggregate	27-68

TABLE 2
Participants and Total Meetings of Five VCPs

Topic(s) of VCP	Spring/Summer 2020		Fall 2020	
	Attendance	Meetings	Attendance	Meetings
Laboratory	15-40	22	4-16	15
Design	5-13	7	3-10	13
Mass and Energy Balances + Thermodynamics	9-13	7	10-27	8
Transport Phenomena + Separations	4-7	7	5-9	12
Reaction Engineering + Control (+ Computing in Fall 2020)	5-12	7	5-6	10

MEB/Thermodynamics VCP (Facilitators: Liberatore, Silverstein, Velegol, Wheeler West). During the first VCP meeting for MEB/Thermodynamics in Spring 2020, participants were polled to determine what were their most pressing needs. Those results drove the agendas for the subsequent five meetings, and included topics such as student engagement, test/exams and alternatives, successes and failures, and educational pedagogy. For student engagement, faculty members shared their experiences using polls, surveys to check understanding, and using breakout rooms to encourage student interaction. In addition, Margot Vigeant shared ways of connecting outside of class using platforms such as GroupMe®, Slack, Microsoft Teams®, Discord®, and G-chat®. Some survey results additionally showed what apps students were already using at the time. Finding ways to assess student learning while maintaining academic integrity was facilitated by David Silverstein with contributions from Adam Melvin and Sean Walker. Specifically, proctoring exams online using applications/services such as ProctorU® and Respondus®. Similarly, Stephanie Velegol shared her experiences proctoring exams using breakout rooms with Zoom. Other ideas/best practices included randomizing the questions/numbers and giving projects instead of exams. At the end of the semester, faculty members shared their successes and failures from their rapid transition to virtual learning as a way of encouraging each other and providing ideas for the next term. The purpose of the last meeting was to brainstorm educational research questions that could be answered by future educational scholarship.

One technique used to both facilitate discussion and to avoid monopolization by a single participant was single slide prompts (Figure 2). While many sessions centered around a theme during the Spring 2020 MEB/Thermo VCP, more general check-ins allowed everyone to report back to the group on their successes and struggles. Finally, some summative reflective questions were used to both document as well as encourage planning for the next teaching term. While some participants prepared detailed responses to the prompts hours or days before the VCP meeting, others would add their contributions during the sessions, which leverages the convenience of cloud-based sharing, using Google Slides® in this case.

The Fall 2020 VCP for MEB and thermodynamics attempted to build on the productive discussion during the emerging response of the spring term. Those participating elected to reduce the meeting frequency to biweekly meetings. The first meeting started with collecting participant input on the biggest challenges they expected for the fall. The biggest challenges involved inclusive engagement and assessments that lessened academic misconduct. Other topics recommended for discussion during the term included community building, mode selection, project and teamwork, and time management. Following the development of the agenda for the term, the VCP received an asynchronous appearance by Lisa Bullard,

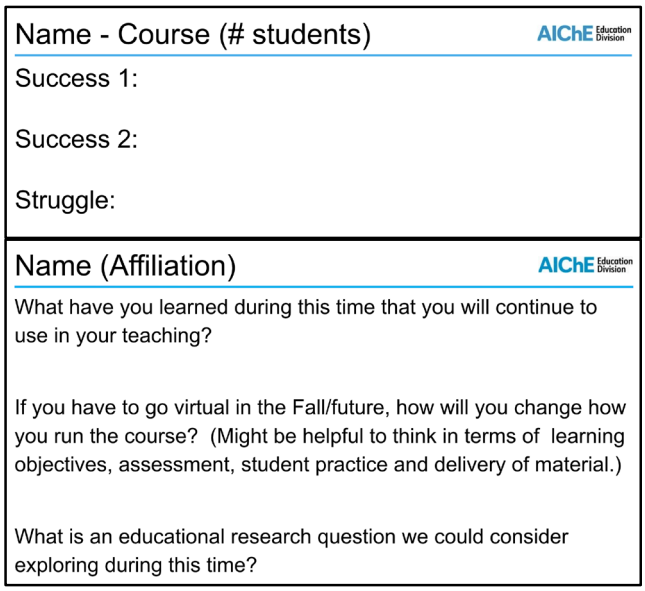

Figure 2*. Prompts used by the Spring 2020 MEB/Thermodynamics VCP. Top: A check-in slide to allow successes and struggles to be documented and facilitate shared discussion and locate common issues. Bottom: Reflective questions to seed educational and research questions.*

co-author of *Elementary Principles of Chemical Processes* (4th Edition), to discuss new online resources in the text that might be useful when teaching in mixed or online modes. The remainder of the meetings addressed the recommended topics, including a very active discussion of inclusiveness to engage all students despite the challenges associated with the pandemic conditions. Additional presentations during the term featured an introduction to Chegg® and a cautionary tale (Sean Walker), description of resources for training students in academic integrity (Adam Melvin), descriptions of alternative assessment methods (other than exams), and ideas for supporting student mental health (Sarah Wilson). The remainder of the VCP cohort term was used for less structured discussion and post-course reflections.

Reactor/Control/Computing VCP (Facilitators: Ford Versypt, Kipper, Raikar, Silverstein). The Reactor/Control/Computing VCP met throughout the Spring and Fall 2020 semesters for the purpose of supporting instructors assigned to teach courses on chemical reaction engineering/reactor design/kinetics, process control, and numerical methods/computing. During the Spring 2020 semester, this VCP did not explicitly include the topics of numerical methods/computing. The courses were grouped together because they all traditionally have a significant mathematical component consisting of analytical and/or numerical methods.

The main topics were exam procedures, student engagement, and resources for simulations, virtual demonstrations, and course projects. As the group started at mid-semester,

major concerns included midterm exams and how to fairly translate these to the digital environment with different technology access. The VCP format was particularly helpful as participants could share about their plans in one session, report back about positive and negative experiences in the next session, and others who were on a different schedule could benefit from those lessons to improve and refine their exam procedures. The exam formats ranged from video proctoring to open-book extended take-home exams to online randomized question bank. Some flexible exam policies were advocated for, such as dropping the lowest exam or making the final exam optional or only counted if the score benefitted a student's final grade.

Most of the courses taught by the participants included a course project, simulations, or demonstrations. Examples of online resources through the CACHE Corporation and Learn ChemE were shared, along with projects used by facilitator Ashlee N. Ford Versypt and John Hedengren's temperature control lab Arduino device.[23-26] Finally, the group discussed ways to foster student engagement, provide support, and gauge feedback. Some suggestions included providing clarified adapted syllabi, seeking input during virtual office hours, polling/surveying students, free responses (on Google Docs®, Zoom whiteboard, or other similar platforms), and discussions during class sessions to give students opportunities to share how they responded to the changes or to mention issues that arose. One of the biggest lessons learned from the Spring 2020 experience was to reserve synchronous contact time for activities where more active learning occurs.

In Fall 2020 the VCP continued to meet, added the scientific/engineering computing topic, and moved to a biweekly schedule after a few weekly meetings. Most of the participants had taught a course in spring that had to be moved online on very short notice. In contrast, fall courses had the advantage of much more deliberate planning and familiarity with online learning and teaching tools among both instructors and students. Some universities had implemented initiatives or developed some guidance to help faculty with online transitions. While the topical discussions in spring were oriented towards helping instructors find and implement solutions to immediate problems, the tone of the discussions in fall was more deliberative and was usually focused on improving online teaching. The VCP participants discussed the approaches various universities used, including fully online and hybrid. Faculty members shared how course content delivery and assessments had changed due to the online shift.

The VCP hosted two guest speakers: John Hedengren, who discussed an inexpensive lab kit that he developed that can be used to simulate temperature control using a USB device, and Bob Rice (Control Stations), who presented the Loop-Pro™ software that can be used to simulate and illustrate common control scenarios and to train students on controller tuning exercises. These guest presentations helped to focus the VCP on strategies for improving learning experiences for students. Other discussion topics included how to adapt common active learning activities (e.g. in-class polling, think-pair-share, small group discussions, empty outlines, etc.) to remote-synchronous, remote-asynchronous, and physically-distanced classroom learning modes. Additionally, a social hour allowed for bonding over a game of Among Us™.

Design VCP (Facilitators: Patton Luks, Vogel). The Design VCP met weekly through the spring semester and most of the fall semester, moving to a biweekly format in November with a final session in January to wrap up the Fall 2020 term and begin thinking about Spring 2021 plans. The sessions were casual gatherings with discussions relating to the immediate needs of faculty participating live. Occasionally, a participant would ask a "How did you do that?" question that could not be answered simply. When that happened, the subsequent session would often begin with a brief presentation addressing the difficult question. Early on, the bulk of the discussion consisted of sharing best practices for teamwork, coaching each other through techniques for accessing simulation software, and generally providing support for each other. In the fall the group moved to discussions of course content and the best way to teach design in a virtual format.

Remote access of simulation software was one of the most significant issues. Most schools use either Aspen HYSYS or CHEMCAD™. Some schools require the students to use a university-owned computer to access the license, and others allow all students to load a copy on their own computer and use their university credentials to access the licenses. This discussion was a valuable tool in aiding faculty members regarding initiating conversations about access with their IT departments or changing software with limited access. The group served as a resource for learning the new simulation software when changes had been made.

Teamwork was another common topic. The group discussed methods of assigning teams and other topics associated with teamwork dynamics. Due to social distancing guidelines, some of the team assignment approaches were modified to create teams within an already established pod where possible. The group discussed Gantt charts, bullet lists, and agile processes (e.g. Scrum.org™) as approaches for organizing teamwork.

The COVID-19 pandemic also brought about changes to how design instructors approach creating teams and introduced new challenges in recruiting colleagues to assist with evaluating projects. Alternatively, alumni and industry partners were able to help out with poster sessions or advising a team much more easily in the remote setting. Some VCP members shared links to student presentations. Viewing a full final presentation allowed instructors an opportunity to compare and benchmark aspects of design projects with other universities. Prior to the online format, these comparisons were typically only done in an advisory board setting.

Presentation of final designs via web calls was a challenge during the Spring 2020 term. However, as design instructors and students seemed more acclimated to virtual instruction in the Fall 2020 term, these presentations seemed less challenging. Some schools had the students present over a web call; some had the students pre-record their presentation and hold a live question and answer session; and some switched to a poster session with Twitter® discussions.

A significant portion of the time was spent sharing ways to incorporate safety into lecture and/or design projects. Various ideas included having students give a Safety Moment presentation during the semester, lecturing about safety material, and having students prepare a P&ID and perform a Process Hazard Assessment of some variety. HAZOP analysis was the most common. The group also shared many technical tips, such as favorite heuristics, how to estimate the price of goods, means of encouraging professional behavior, and resources for creating or selecting design projects.

Lab VCP (Facilitators: Carter, Ford, Pascal). The Lab VCP met nearly every week from March-December 2020, including spring, summer and fall academic terms. Each term had a different emphasis: immediate concerns for Spring 2020, preparing for the fall semester during Summer 2020, and ongoing support during Fall 2020. During the Spring 2020 semester, the main concern of faculty was how to best achieve the goals of the laboratory courses after a sudden transition to remote learning. Some faculty members had enough warning to get teaching assistants into the labs to create videos of equipment and generate datasets for students to analyze. Other faculty members provided data pulled from old lab reports. Faculty members shared resources for procedure and equipment videos online along with online simulations from learncheme.com and the AIChE Concept Warehouse.[27,28] After the initial focus of figuring out how to complete the Spring 2020 semester, the VCP discussed typical lab course learning objectives.[29] Generally, faculty members decided that the students had been able to get enough hands-on experience in the first part of the Spring 2020 semester and focused on other learning objectives, such as data analysis, design of experiments, and teamwork for the balance of the term. Discussions also included how to continue meetings with teams for monitoring teamwork, advising students, and concerns about student mental health.

Summer 2020 focused on helping faculty prepare for the Fall 2020 term. Many guest speakers gave presentations about virtual laboratories, at-home experiments, COVID-19 safety protocols, and remote access to equipment. Faculty who were teaching labs over the summer shared what did and did not work well. As new faculty joined, they were encouraged to consider which learning objectives of Feisel and Rose[29] were important to their courses and how they could combine the available tools to meet those objectives. A list of tools and a "start here" document was shared with the VCP members. A frequent topic of casual conversation was comparing the teaching modes (in-person, hybrid, remote) and COVID-19 testing policies for faculty and students from the various universities.

In the Fall 2020 semester the assumption was that most faculty members had already created their plans for the term, so the VCP switched to a support mode. Scheduling a meeting that everyone could attend was challenging, so summaries were posted on a Slack Channel®, and participants were encouraged to reach out through Slack for support as needed. The tool list and "start here" document were shared with incoming faculty as needed, and the tool list was posted on a webpage.[28] Teamwork problems were frequently discussed, particularly involving a remote student on a team with in-person students. Additionally, COVID-19 safety policies among the participants were discussed, and advice on how to adjust laboratory deliverables for students who had to quarantine was shared. Monitoring and advising students remotely were concerns, just as they were in the Spring 2020 term.

At the end of the term, the participants discussed what did and did not work well in each of their labs. Overall, the faculty members were satisfied they had met their course objectives (although possibly altered from earlier terms) through alternative assessments, the use of simulations, and instructional videos.

Participant Feedback

Two surveys were distributed to participants in August and December 2020, which are designated as Spring/Summer 2020 and Fall 2020, respectively, in this section. The response was 31 participants in Spring/Summer 2020 and 32 in Fall 2020. Based on average attendance, the response rate is estimated to be between 50% and 67%, which is similar to other VCP surveys.[13] Beginning with participation information, 61 % of respondents participated fully synchronously with the rest mostly synchronously in the Spring/Summer 2020. In Fall 2020 47% were fully synchronous, 38% mostly synchronous, and 16% mostly asynchronous. This shift to some asynchronous participation may be related to time conflicts with the synchronous group or a desire to gain information without contributing to the group. Next, 93% of respondents in Spring/Summer 2020 and 100% in Fall 2020 engaged at least 1 or 2 hours per week with a VCP. All of the VCPs were represented by many respondents, with 48% and 41% participating in more than one VCP during Spring/Summer and Fall 2020, respectively.

Next, two sets of questions were asked about being introduced to and then applying topics related to either pedagogy or technology. Seven pedagogy topics were included (Table 3), and four topics received over 60% response for both surveys. Student assessment, teamwork, and engagement had the highest response rates for both surveys. While not explicitly asked,

assessment discussions often included discussions on the challenges of academic dishonesty, cheating, and plagiarism when administering remote exams and other forms of assessment. The two topics with significant changes were Bloom's Taxonomy and Diversity, Equity, and Inclusion. Discussion of Bloom's Taxonomy likely shows the additional preparation and reflection time that the VCP leaders and participants had in the fall compared to the abrupt campus shutdowns in March. The increase in Diversity, Equity, and Inclusion topics likely has multiple possible explanations, including faculty's first-hand experience with the socioeconomic inequities of remote instruction in the spring, as well as widespread social justice protests, including those related to racial inequity, that occurred during Summer 2020.

Introducing and discussing pedagogical topics in a VCP are only part of the objective of the groups. Adopting new strategies in real time more completely quantifies the impact of the VCPs. "Many times," "One time," and "Never" were the choices for adoption related to the seven topics (Figure 3). Adoption rates above 70% were observed in both surveys for engagement, teamwork, assessment, and active learning. Diversity, Equity, and Inclusion saw a significant shift from 30% to 55% adoption of one or many times.

Technology tools showed similar introduction rates in Spring/Summer and Fall 2020 (Table 4 and Figure 4). Other software tools increased almost 30%, while video editing decreased 16% from Spring/Summer to Fall 2020. Since video recording and editing became commonplace in the spring, less discussion centered around this topic. However, web-based video platforms had both the highest introduction and adoption in both time periods. One explanation could be the significant updating and introduction of new features across most platforms, e.g. the addition of breakout rooms and other collaborative tools. Both learning management systems and video creation saw decreases in introduction with time, which likely indicates that faculty were more comfortable with using these tools after teaching remotely during the spring.

Next, two questions related to the creation of a community were asked. All participants (100%) across both surveys agreed that the VCPs are a welcoming community. Another question asked about meeting new people. In Spring/Summer 2020 90% of the respondents met 3 or more new people, and 61% met 5 or more new people. In Fall 2020 97% of the respondents met 3 or more new people,

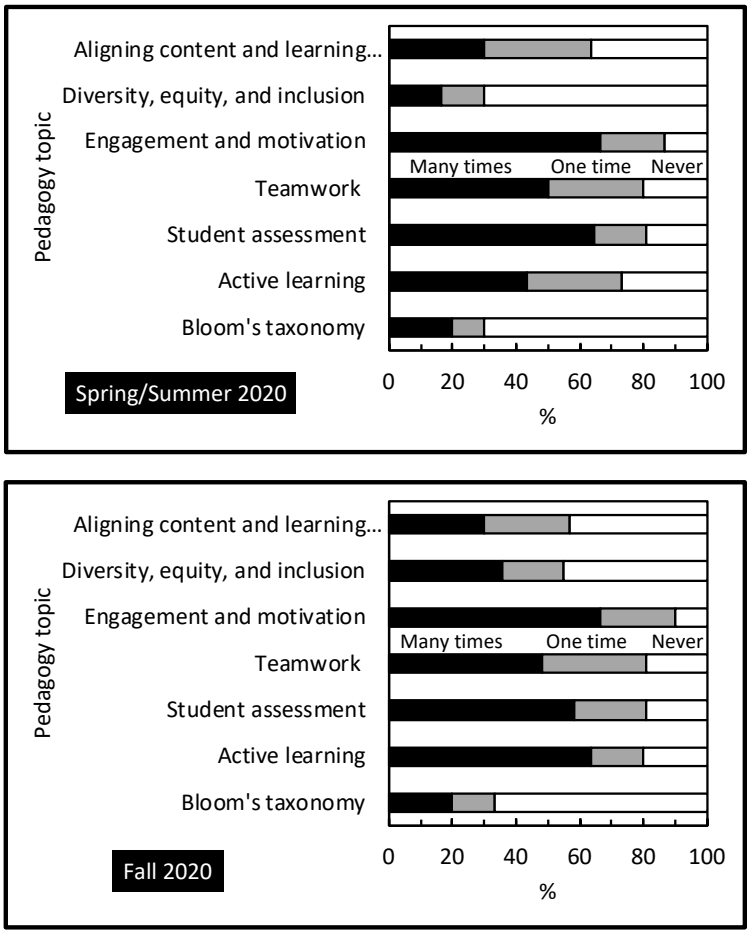

Figure 3. *Fraction of participants responding many times, one time, or never across seven pedagogy-related topics for Spring/Summer 2020 (top) and Fall 2020 (bottom).*

TABLE 3
Participants Selecting Agree or Strongly Agree to Being Introduced to Different Pedagogy Topics.

Pedagogy Topics	Spring/Summer 2020 (%)	Fall 2020 (%)
Aligning Course Content and Course Learning Objectives	70	77
Diversity, Equity, and Inclusion	28	75
Student Engagement and Motivation	74	90
Teamwork and Cooperative Learning	76	94
Student Assessment (Quizzes and Exams)	77	90
Active Learning	62	87
Bloom's Taxonomy	14	45

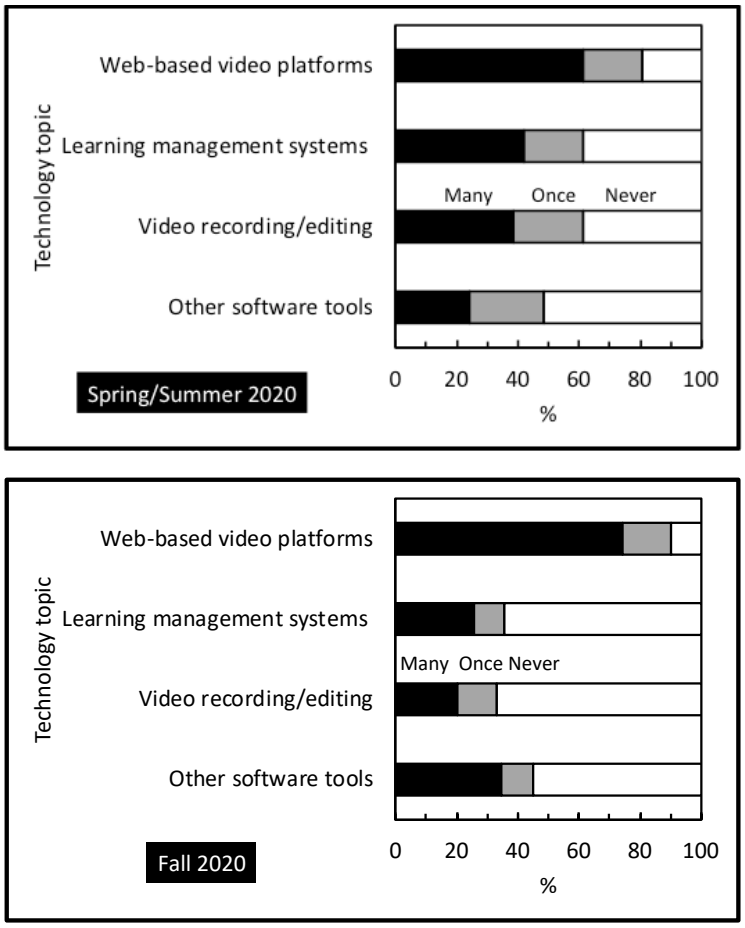

Figure 4. *Fraction of participants responding many times, one time, or never across four technology-related topics for Spring/Summer 2020 (top) and Fall 2020 (bottom).*

TABLE 4
Participants Selecting Agree or Strongly Agree to Being Introduced to Different Technology Topics

Technology Topics	Spring/Summer 2020 (%)	Fall 2020 (%)
Web-based Video Platforms (Zoom, WebEx, Microsoft Teams, Blackboard Collaborate, etc.)	84	94
Learning Management Systems (Blackboard, Canvas, Moodle, etc.)	55	50
Video Creation, Screencasting, or Similar Video Recording/Editing	63	47
Other Software Tools	46	77

and 84% met 5 or more new people. Combining these survey findings with the AIChE member data (Table 1), the VCPs impacted faculty across rank, location, AIChE or AIChE Ed Div member status, and beyond.

Finally, three summative questions completed the survey (Table 5). The response to all three questions was nearly unanimous, which indicates a high level of success for all participants. Some free response comments were also entered; they were generally strongly positive, with many mentions of gratitude to the organizers and leaders.

With many common topics discussed across the VCPs, the information was shared in many ways. Since some faculty participated in more than one VCP, cross-communication was common. Also, the leader meetings encouraged sharing of discussion points and findings between the VCPs. Finally, while there was frequent sharing of information materials done within each specific VCP, concerns about privacy and items being accessible in the public domain without the owner's consent confined the materials to the VCPs with access available upon request.

CONCLUSIONS

The AIChE Education Division VCP program delivered an engaging framework to support chemical engineering faculty during the COVID-19 pandemic. The VCPs provided faculty with a regularly-scheduled professional development opportunity that supported their efforts in online instruction and incorporated specific educational topics, such as technology, assessment, student engagement, and mental health and wellbeing. This program was developed from past experiences of Virtual Communities of Practice, which were designed to inform faculty members of evidence-based pedagogical techniques for primarily in-classroom instruction.[13] The educational footprint of this program was significant – over 190 unique participants from over 100 institutions and nine countries engaged with the program. Furthermore, more than half of these interested participants were not members of the AIChE Ed Div.

Five VCPs were organized by one or a group of course topics. Summaries from each VCP highlighted similarities and differences in organization and structure of the virtual meeting. Many guest

TABLE 5
Participants Selecting Agree or Strongly Agree to Being Introduced to Different Technology Topics

Technology Topics	Spring/Summer 2020 (%)	Fall 2020 (%)
Overall, participating in the VCP improved my teaching during the (time period) of 2020.	87	100
Overall, I would recommend participating in a VCP to other faculty in my department.	94	100
Overall, I will participate in the same or another VCP in the future.	87	100

speakers provided specific expertise on a product or resource that could be applied in the course(s) of interest. Overall, regular attendance involved between 25 to 85 faculty during any 1-2 week period during the Spring/Summer and Fall 2020 terms.

The three VCPs related to core courses focused on many similar topics, including student engagement, technology tools for active learning, assessment practices, and academic dishonesty prevention. The design VCP also focused on team dynamics and outcomes related to team projects. Finally, the lab VCP included discussions about virtual laboratory and simulation options, as well as strategies for in-person and hybrid labs amid social distancing restrictions.

As shown from the survey results and analysis, over 87% of the faculty members who participated in the program indicated that they had a positive experience and that the program impacted their teaching. These faculty members planned to participate in future VCPs and recommended the program to other faculty members in their department.

In conclusion, the AIChE Education Division VCP program was and continues to be an important initiative that had significant impact on chemical engineering education during an extremely stressful and uncertain time for chemical engineering faculty and the broader higher education community. Furthermore, this program demonstrates, and perhaps embodies, the value of professional societies, such as AIChE and its Education Division, as shown by the impact of providing professional development and networking opportunities for its membership throughout challenging times, in this case, the COVID-19 pandemic.

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REFERENCES

1. Borrego M and Henderson C (2014) Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education*. 103(2):220-252. DOI: https://doi.org/10.1002/jee.20040.
2. Rogers EM (2003) *Diffusion of Innovations*. 5th ed. Free Press. New York, NY.
3. Wegner E (1998) *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press. Cambridge, UK.
4. Coto M and Dirckinck-Holmfeld L (2008) Facilitating communities of practice in teacher professional development. Proceedings 6th International Conference on Networked Learning.
5. Sherer PD, Shea TP, and Kristensen E (2003) Online communities of practice: A catalyst for faculty development. *Innovative Higher Education*. 27(3):183-194. DOI: https://doi.org/10.1023/A:1022355226924.
6. Lock JV (2006) A new image: Online communities to facilitate teacher professional development. *Journal of Technology and Teacher Education*. 14(4):663-678. DOI: https://www.learntechlib.org/primary/p/21030/.
7. Faber C, Smith-Orr C, Bodnar C, Coso Strong A, Lee W, and McCave E (2017) Best practices for developing a virtual peer mentoring community. *Proceedings ASEE Annual Conference & Exposition*. DOI: https://peer.asee.org/27655.
8. Streveler RA, Lichtenstein G, Olcese L, Brunhaver SR, Carrico C, Chen HL, Matusovich HM, and Sheppard S (2018) Professional engineering pathways study: The value of a community of practice to stimulate use of research findings that inform practice. *Proceedings ASEE Annual Conference & Exposition*. DOI: https://peer.asee.org/29942.
9. Krause SJ, Hjelmstad KD, Judson E, Middleton JA, Culbertson RJ, Ankeny CJ, Chen Y, Ross L, Mayled LH, and Hjelmstad KL (2018) Assessing faculty and organizational change in a professional development program with workshops and disciplinary communities of practice. *Proceedings ASEE Annual Conference & Exposition*. DOI: https://peer.asee.org/29820.
10. Ross L, Mayled LH, Krause SJ, Judson E, Hjelmstad KD, Middleton JA, Culbertson RJ, Ankeny CJ, Chen Y, Hjelmstad KL, Glassmeyer K, and Hoyt S (2019) Scaling and assessment of an evidence-based faculty development program for promoting active learning pedagogical strategies. *Proceedings ASEE Annual Conference & Exposition*. DOI: https://peer.asee.org/32240.
11. McKenna A, Johnson AM, Yoder B, Chavela Guerra RC, and Pimmel R (2016) Evaluating virtual communities of practice for faculty development. *The Journal of Faculty Development*. 30(1):31-40.
12. Courter SS, Freitag C, and McEniry M (2004) Professional development online: Ways of knowing and ways of practice. *Proceedings ASEE Annual Conference and Exposition*. DOI: https://doi.org/10.18260/1-2--13833.
13. Farrell S, Krause SJ, Ruzycki N, Genau AL, Nelson-Cheeseman B, Bodnar CA, Shih JD, Lepek D, Corneal L, Ciston S, and Eitel RE (2015) A virtual community of practice to introduce evidence-based pedagogy in chemical, materials, and biological engineering courses.

Proceedings ASEE Annual Conference & Exposition. DOI: https://doi.org/10.18260/p.23473.
14. Dancy M, Lau AC, Rundquist A, and Henderson C (2019) Faculty online learning communities: A model for sustained teaching transformation. *Physical Review Physics Education Research*. 15(2):020147. DOI: https://doi.org/10.1103/PhysRevPhysEducRes.15.020147.
15. Martin CC, Newstetter WC, and Le Doux JM (2019) Inclusion requires a comprehensive understanding of justice. *Journal of Engineering Education*. 108(4):453-458. DOI: https://doi.org/10.1002/jee.20296.
16. Deslauriers L, McCarty LS, Miller K, Callaghan K, and Kestin G (2019) Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Science*. 116(39):19251-19257. DOI: https://doi.org/10.1073/pnas.1821936116.
17. Theobald EJ, Hill MJ, Tran E, Agrawal S, Arroyo EN, Behling S, Chambwe N, Cintron DL, Cooper JD, Dunster G, Grummer JA, Hennessey K, Hsiao J, Iranon N, Jones L, 2nd, Jordt H, Keller M, Lacey ME, Littlefield CE, Lowe A, Newman S, Okolo V, Olroyd S, Peecook BR, Pickett SB, Slager DL, Caviedes-Solis IW, Stanchak KE, Sundaravardan V, Valdebenito C, Williams CR, Zinsli K, and Freeman S (2020) Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. *Proceedings of the National Academy of Sciences*. 117(12):6476-6483. DOI: https://doi.org/10.1073/pnas.1916903117.
18. Wankat PC and Oreovicz FS (2015) *Teaching Engineering*. 2nd ed. Purdue University Press. West Lafayette, IN.
19. Silverstein DL and Wilson S. Effective Practices for Teaching Chemical Engineering Undergraduates Online. https://www.aiche.org/academy/webinars/effective-practices-teaching-chemical-engineering-undergraduates-online accessed February, 2021.
20. AIChE Code of Ethics. https://www.aiche.org/about/governance/policies/code-ethics accessed February, 2021.
21. Kahoot! https://kahoot.com accessed February, 2021.
22. Helminski L and Koberna S, Total Quality in Instruction: A Systems Approach. *Academic Initiatives in Total Quality for Higher Education*, Roberts, H. V., Ed. ASQC Quality Press: Milwaukee, WI, 1995; pp 309-362.
23. Ford Versypt AN (2017) Choose your own kinetics adventure: Student-designed case studies for chemical reaction engineering Course Projects. *Transactions on Techniques for STEM Education*. 3:48-56.
24. Park J, Martin RA, Kelly JD, and Hedengren JD (2020) Benchmark temperature microcontroller for process dynamics and control. *Computers & Chemical Engineering*. 135:106736. DOI: https://doi.org/10.1016/j.compchemeng.2020.106736.
25. Computer Aids for Chemical Engineering Teaching Resources. https://cache.org/teaching-resources-center accessed February, 2021.
26. LearnChemE Interactive Simulations. http://www.learncheme.com/simulations accessed February, 2021.
27. LearnChemE - Educational resources for chemical engineering. http://www.learncheme.com/ accessed February, 2021.
28. AIChE Education Division's Concept Warehouse. https://jimi.cbee.oregonstate.edu/concept_warehouse/ accessed February, 2021.
29. Feisel LD and Rosa AJ (2005) The role of the laboratory in undergraduate engineering education. *Journal of Engineering Education*. 94(1):121-130. DOI: https://doi.org/10.1002/j.2168-9830.2005.tb00833.x. ❐