# Virtual Community of Practice: Electric Circuits

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## Abstract

Disseminating effective practices for engineering education requires developing pedagogical communities that bring together faculty from many institutions. Through an NSF-funded ASEE effort aimed at facilitating faculty development in research-based instruction, we led an online Virtual Community of Practice (VCP) around the teaching of introductory Electric Circuits. The VCP comprised 20 faculty members who were broadly diverse in terms of geography, institutional characteristics, and teaching experience. Meetings were held using Adobe Connect, with materials shared and discussions held through an online portal built with Open Atrium. This platform carried many advantages – such as allowing a large group to interact and view a common presentation, while also facilitating smaller break-out groups – but it also posed logistic issues inherent into any use of technology for group interactions. Leaders of the circuits VCP – along with VCPs on other topics in electrical engineering – were trained by a Leadership VCP in advance of its sessions.

The Electric Circuits VCP consisted of 9 weekly 90-minute sessions during Spring 2013, each including learning objectives and an assignment for participants. There were also 5 sessions during Fall 2013. Breakout groups within each session promoted interactions among subsets of the participants; these were critical for encouraging broad participation, with each breakout group reporting back to the full VCP afterward. Pre-planned topics included (1) Introduction to the Circuits VCP, (2) Overview of Research-based Instructional Approaches, (3) Learning Objectives and Bloom's Taxonomy, (4) Student Motivation, (5) Teams, and (6) & (7) Making the Classroom More Interactive. The topics for sessions (8) and (9) were developed by our VCP community during preceding weeks: (8) Simulation and Hands-On Learning, Assessing Impact; (9) Great Ideas that Flopped. In addition to the weekly meetings of the entire VCP, participants interacted via ad hoc small-group meetings, email and polling to collect opinions and ideas, and additional material provided after each session.

Nearly all participants reported that they are making significant changes in their Circuits courses based on their VCP experience. Topics that elicited the most interest from the participants, based on their post-VCP feedback, were: (1) Flipped Classrooms; (2) Hands-On Learning based on Inexpensive Measurement Hardware; (3) Assessment. Participants are also developing topics for collaborative research and a workshop to share what they have learned with faculty from other institutions. Leaders in implementing flipped classrooms, MOOCs, and other new pedagogy have also been invited to work with the group both offline and during regular meetings.

The VCP model proved to be effective at establishing a diverse pedagogical community, without the resource and time constraints of regular in-person meetings. There are still some limitations, however. Those faculty who are particularly dedicated to undergraduate instruction – and thus are the best candidates to participate in a VCP –often have limited time for activities that may not have immediate impact on their daily responsibilities. Also, interactions in large online groups may not suffice to promote a strong working relationship. Based on the personal

experience of the authors, a substantive collaboration requires regular online face-to-face interaction followed by additional electronic exchanges as materials are finalized. Despite these limitations, our initial implementation of the VCP model provides a guide for other groups to create similar virtual communities for other aspects of engineering education.

## 1. **VCP Structure and Goals**

The Virtual Community of Practice (VCP) program grew out of a collaboration between the National Science Foundation (NSF) and the American Society for Engineering Education (ASEE). The chief goal of the VCP program is to develop interactive, collaborative communities of instructors who share common goals (e.g., approaches, courses). The emphasis on *virtual* communities springs from two recognized challenges in engineering education. First, advances in engineering education need to be disseminated to the broad pedagogical community, both to increase their impact and to ensure effective assessment. Second, the traditional model of interaction through short-term, one-shot, and face-to-face workshops presents significant challenges of cost and scale – and thus while such workshops remain unquestionably valuable (e.g., as ancillary events at major conferences), they are limited in both the breadth and depth of their community reach. To overcome these challenges, the NSF-ASEE VCP model seeks to create an online virtual community in which participants interact using free or low-cost technology, without geographic constraints.

## 2. **VCP Organization and Supporting Technology**

The Circuits VCP attracted a geographically and institutionally diverse set of participants. The 20 active participants were chosen from 34 applicants, with the goal of having as diverse a group of universities represented as possible, without going outside the US, with first priority given to instructors of introductory circuits courses. Figure 1 illustrates the breadth of geographic reach for the VCP program – participants were spread throughout the US and four time zones. This dispersion points out a key advantage of the VCP model: it allows participants to interact with colleagues repeatedly, at a fraction of the cost of a single workshop. Only 2 of the participants were known to either co-leader and both were chosen because they were good collaborators. Figure 2 illustrates the institutional diversity of our participants, using “size of institution” as a proxy measure. There were participants from small- and mid-sized public and private universities, as well as from very large public universities. The majority of our participants came from institutions with between 10,000 and 20,000 students, potentially reflecting the distribution of engineering faculty and students more generally.

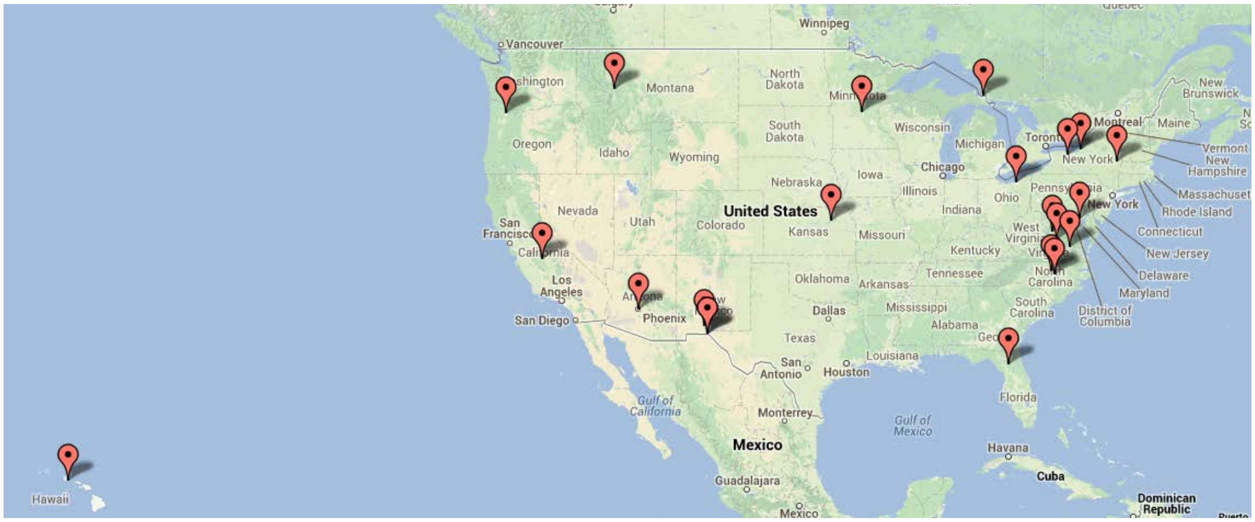

Figure 1. Locations of home institutions for Circuits VCP participants.

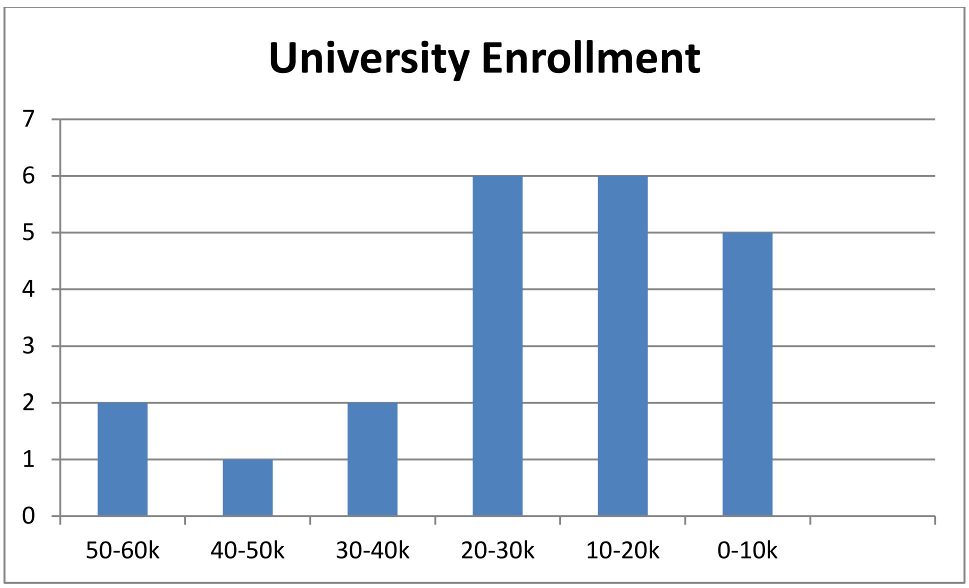


Figure 2. Histogram showing the number of Circuits VCP participants as a function of school size.

2.1 Open Atrium Portal

The primary resource used for sharing information and ideas within the group and for access to meeting recordings and notes was an online collaboration and task management site using Open Atrium. Included were a blog for sharing ideas, a notebook for posting meeting recordings, folders for access to the materials used in each session, a meeting calendar and a directory of participants. The most used portal component was the folders. The general structure of the portal was developed and maintained by ASEE personnel, who also provided troubleshooting help when difficulties occurred. There were very few technical problems in the Circuits VCP because of the training we were provided and the experience we obtained during the training sessions for VCP leaders.

2.2 Adobe Connect

Meetings were conducted using the Adobe Connect web conferencing platform. All online collaboration tools have their issues, but we had very few problems, again because of our training and simple instructions from ASEE that we shared with our participants. For all meetings, we used computers both for video and audio, rather than using phone lines for audio. We did not use webcams very often. When we did, we ran into bandwidth limitations that caused one or two participants to have connection problems. We incorporated a variety of Adobe Connect features including breakouts, chat, notes, and polls. All were quite useful, with breakouts and chats the most effective. Meetings were recorded and posted to the Open Atrium portal, the chat window was saved and posted to portal, and slides were posted to the portal in advance of the meeting.

## 3. **Virtual Meetings**

Circuits VCP online meetings largely addressed topics covered in the Leadership VCP training that the co-leaders attended prior to launching their VCP. The Leadership VCP was also organized in a manner that was transferable to the disciplinary VCPs. A description of each session is provided in the following section. Utilizing both content and infrastructure from the Leadership VCP made implementation of the Circuits VCP much easier. However, tailoring the meetings for the specific participants did require a significant amount of work and additional meetings of the co-leaders. The co-leaders prepared for each meeting by holding a weekly Skype or Adobe Connect meeting to develop the meeting structure, discuss readings and design activities, and to divide the preparation work. Both the co-leaders found the active working relationship facilitated by these meetings and follow up emails and portal postings to be quite productive and rewarding. The co-leaders were not acquainted before the program began and did not meet in person until the ASEE Conference in Atlanta, well after the Spring 2013 sessions were completed.

### 3.1 Spring Sessions

The Circuits VCP met weekly for 90 minutes for nine weeks in the Spring 2013 semester, beginning on March 21$^{st}$ and ending on May 19$^{th}$. Each week followed a similar format: participants did some preparation in advance (e.g., read an article or prepare an example from their own teaching), the meeting started with the co-leaders facilitating a broad discussion of the week's topic, followed by discussion and activities related to the topic (often conducted in smaller break-out groups), and concluding with full-group report-out and synthesis of the ideas raised during the discussions. The following provides a general overview of the nine sessions:

***Week 1: Introduction to the Circuits VCP***. Being the first gathering of the VCP participants, our primary goals for this first session were related to community building: allowing participants to meet each other, providing an overview of the structure and goals of the Circuits VCP, and demonstrating the technology we would be using to facilitate our interactions.

***Week 2: Overview of Research-based Instructional Approaches.*** This week represented the first engagement by VCP participants with pedagogical materials. We assigned two readings that were intended to introduce key concepts underlying research-based instructional approaches and relate these principles to concrete instructional strategies: the "Introduction" and "Conclusion" chapters from *How Learning Works* by Ambrose *et al.*[1] and Chickering and Gamson's article "Seven Principles for Good Practice in Undergraduate Education"[2]. VCP participants were each assigned one of those principles, individually, in advance of our online meeting and asked to identify a previous experience of something related to that principle when teaching circuits (or another course, if they had not taught circuits before). The online session began with breakout sessions involving pre-assigned groups; each group selected one individual to record notes and to summarize their discussion to the larger VCP. Within the breakout session, participants discussed the examples from their own experience – and from those examples restated their group's principle from an instructor's perspective. A final VCP discussion synthesized the output of the breakout sessions.

***Week 3: Learning Objectives and Bloom's Taxonomy.*** This session explored the nature of learning objectives, as derived from psychological and pedagogical theories of learning. At the beginning of this session, we polled participants about the principles discussed in Week 2, including both possible extensions in their own courses and the challenges involved in applying those principles. Participants were assigned a text about learning objectives (Appendix D from *How Learning Works*[1]) and two web resources associated with Bloom's Taxonomy[3,4]. The VCP co-leaders presented an overview of learning objectives in the context of engineering education (e.g., ABET assessment), challenges in aligning course content to objectives, and taxonomies of learning. Each break-out group was assigned three learning objectives from a typical introductory circuits course, as well as course catalog descriptions for three other circuits courses. The groups then re-wrote one of the objectives from the introductory course and wrote one objective for one of the other courses, based on the prior discussion about learning theory. The revised and new objectives from each group were shared with the larger VCP, which discussed how to create meaningful learning objectives that facilitate good pedagogy.

***Week 4: Student Motivation.*** This session considered the psychological concepts of expectancy and value – and how strategies for establishing expectancies and value could be applied to increase student motivation. In advance of the session, participants read two articles (Chapter 3 from *How Learning Works*[1] and Idea Paper #41 by Svinicki[5]) that considered the psychological basis of motivation. The VCP co-leaders provided a brief introduction to value (i.e., the desire to obtain a goal) and expectancy (i.e., of achieving a goal or of benefitting even if the goal is not reached), as well as to some established strategies for building positive expectancies. An initial breakout session placed each group in the role of a mentoring committee for a new faculty member who has been assigned to teach Circuits. They were tasked with identifying an approach for motivating students that would not typically be recognized by new instructors and with describing what happens when instructors fail to implement that strategy. The entire VCP then came together for a presentation and discussion of different types of value, along with six strategies for establishing value. Each breakout group was then assigned two of the value strategies (from Chapter 3 of *How Learning Works*[1]) and asked to brainstorm a concrete example in which they implement one or both strategies. A final VCP discussion integrated the different examples from the breakout sessions.

***Week 5: Teams and Scaffolding.*** Given that many engineering curricula have substantial team-based instruction (e.g., laboratory sessions, group projects), we explored the potential benefits and challenges of incorporating team-based activities into circuits courses. Before the session, each participant completed a team-maker survey and read one of two assigned articles[6,7] on effective student teams. An initial presentation discussed challenges associated with forming teams, turning groups of students into interacting teams, assessing students individually when they work in teams, and dealing with social and intellectual differences among students. Via a poll and break-out group activity, participants shared their prior experiences with short projects or other team-based tasks. A second, related topic was included within this session: scaffolding and critical thinking. Participants discussed – both in the whole VCP and break-out groups – how instructors can help students critically assess their own knowledge, so that they can seek help from others and from their instructor.

***Week 6: Making the Classroom More Interactive (I).*** We next began a two-session sequence on interactive activities in circuits courses, with the overall goals of identifying key characteristics of active learning, challenges of implementing in-class activities, and strategies for addressing those challenges. Putting ideas into practice, we utilized the results of the team-maker survey from Week 5 to assign participants to a break-out team and asked each team to (virtually) meet before the sixth VCP session to develop a single well-defined project activity for students in a typical circuits and electronics class. At the beginning of the session, each group reported briefly on their project activity and the topics of discussion that came up during their planning (including team-related issues). Then, a presentation and discussion period considered the nature of active learning and a taxonomy of active learning activities. Then, we implemented a typical active-learning activity – Think-Pair-Share – within the VCP. Participants were provided a set of three discussion questions related to the session's content and were given four minutes to think of their own answers. Then, participants were paired (alphabetically), and each pair was given five minutes to discuss commonalities and differences in their answers – which were then reported back to the rest of the VCP.

***Week 7: Making the Classroom More Interactive (II).*** In the second active-learning session, we focused on evidence for the effectiveness of active learning as implemented via specific strategies. Participants read two articles associated with active learning[8,9], posted an example of how they use active learning to the VCP online portal, and then reviewed the other VCP participants' examples prior to the session. A presentation described different types of active learning – collaborative, cooperative, and problem-based – and considered the challenges involved in assessing the effectiveness of these approaches. An extended break-out session engaged participants by first discussing all of the examples from their group (in a simplified "elevator pitch" format) and then selecting one or two examples for exploration in greater detail.

***Week 8: Simulation and Hands-On Learning, Assessing Impact.*** We reserved the last two weeks of the VCP for participant-suggested topics. One topic that attracted substantial interest from participants was the use of simulation activities in circuits courses; e.g., different models for problem solving within a circuits course, techniques for assessing the impact of those activities on student learning. We considered three publicly available simulation programs appropriate for use in introductory courses. Break-out groups considered two questions: (1) What evidence could show that a particular instructional technique or approach had a positive impact on student learning, and (2) What tools and techniques could be used to collect evidence of impact? Groups were guided to use the discussion of problem solving models from an earlier

VCP session as background context. At the end of the session, groups reported on their ideas for assessing impact of new hands-on methods.

***Week 9: Great Ideas that Flopped.*** Our final VCP session involved an intentionally open-ended discussion in which participants shared challenges they had encountered in the classroom, in order to seed integrative discussions based on what participants learned throughout the VCP. In break-out sessions, participants described an activity they had attempted, including both what worked and what did not work. Other group participants brainstormed possible solutions, trying to identify a key obstacle or constraint and how to deal with it. Each group reported back to the VCP on their activities, challenges, and lessons learned. Then, the entire group considered challenges common to the different activities and the pedagogical themes that emerged.

### 3.2 Fall Sessions

During the second set of sessions, which took place over 5 biweekly 90-minute meetings in Fall 2013, the VCP's focus transitioned to larger pedagogical concepts and issues related to sustainability of our nascent community. The VCP co-leaders recognized that all participants had many demands on their time, which meant that ongoing activities need to offer substantial and practical value – especially given that participants were not receiving direct benefit for their participation. Moreover, to develop a sense of affiliation among the VCP participants, the co-leaders solicited their input about the topics that would be of most value for the group.

Two logistical changes were introduced, in recognition of the maturing VCP. First, the 90-minute meeting sessions were organized into 3 30-minute blocks, with participants welcome to come and go on the half-hour. Second, each meeting was organized around small-group assignments that were based on participants' individual interests; those groups were encouraged to meet outside of biweekly Adobe Connect meetings. Together, these changes allowed participants who were unable to make the full-group meeting to remain engaged with the community, while strengthening the relationships between group members. Note that we explored a structure where the smaller groups met during the weeks between the VCP sessions, but that structure proved challenging because of participants' difficulty in accommodating another meeting on their schedules.

***Meeting 1: Reconvening the VCP.*** Our first Fall session examined how the VCP participation was changing participants' approaches to their fall teaching. Discussions considered what participants took as the major insights from the Spring sessions, what new activities or goals they were adopting in their current teaching, and how they were approaching questions of student motivation and learning objectives. In each case, participants both updated the group on their own progress and sought group feedback for their ongoing challenges. A key goal was to re-familiarize participants with potentially shared activities (e.g., several participants were flipping their classroom for the first time) in order to build relationships among VCP members. We also discussed logistics for the Fall sessions and possible guest experts to invite for discussions.

***Meeting 2: Course Design.*** In advance of the second session, the co-leaders collected examples of case studies for past, present, or planned circuits courses to use as the basis for discussing approaches to course design. In advance of the meeting, participants identified the key characteristics of a single course (e.g., description, target audience, pre-requisites, course components), the facilities and resources available to that course, and its learning objectives. For the online discussion, we conducted a SWOT (Strength, Weakness, Opportunities, Threats) analysis; this provides a framework for identifying what works, what needs improvement, how improvements could be implemented, and the risks associated with making (or not making) changes.

***Meeting 3: Flipped Classroom.*** A recurring topic of interest in both the Fall and Spring sessions was the idea of "flipped" classrooms; i.e., providing traditional lecture or lecture-like materials to students in advance of the class period, and then devoting class time to interactive activities, problem solving, or individual exercises. We invited Dr. Cynthia Furse (University of Utah) to attend our online meeting and to share her experience in flipping the classroom. Dr. Furse started flipping her classroom in 2007 and is planning to flip "Introduction to ECE" (circuits + MATLAB) in Spring 2014. We conducted our session in a flipped model by asking the participants to watch two short video lectures (about 15 minutes total) in advance of the online session[10]**.** Dr. Furse also provided additional materials via her personal website. During the VCP session, participants were able to ask Dr. Furse specific questions about the mechanics of flipping the classroom, tips for success, potential pitfalls and solutions, and other logistical issues.

***Meeting 4: Massive Open Online Courses (MOOCs).*** Because of participant interest in the MOOC model – both generally, and with regard to circuits specifically – we invited Dr. Bonnie Ferri (Georgia Tech) to be a guest expert at our online meeting. Dr. Ferri taught Linear Circuits as a MOOC in the Summer and Fall 2013 semesters. In advance of the meeting, we asked participants to review one or more lectures from the (archived) Linear Circuits course, and to explore the other resources provided to students in that MOOC. Dr. Ferri provided insight into the preparation and execution of a MOOC, the mobile learning platform TESSAL (Teaching Enhancement via Small-Scale Affordable Labs), and the potential for integrating mobile labs with online learning.

***Meeting 5: Conclusions and Reflection.*** In the final online VCP meeting, there was a general discussion about the content of discussions over the past year and how those discussions influenced participants' teaching. Participants were asked to reflect on how their courses went over the past semester and on any new approaches that were implemented because of the VCP. There was also a forward-looking discussion about how to maintain the VCP community, perhaps by identifying specific topics that would be worth exploring in depth on an ad hoc basis. Participants also provided general feedback on the organization and structure of the VCP.

## 4. **Successes and Challenges**

What did we accomplish? Most of the VCP participants were either in the process of implementing a significant innovation in their introductory-level Circuits course or were planning to do so in the near future. The VCP interactions allowed participants to obtain feedback on their ideas and to explore new ideas that made it more likely that their innovations would succeed. In most instances, the participants were working in something of a vacuum with few local colleagues trying anything similar. The group meetings, especially the breakout sessions, nearly always resulted in requests for additional information about ideas heard during discussions. Having someone who teaches a similar course want to duplicate or build on what one is doing helps promote success as much as hearing suggestions for improvement. There were many signs like these of a vigorous community of faculty working to improve the educational experiences of their students, with continued interactions between participants taking advantage of their expanded professional network while writing proposals, doing research and implementing research-based pedagogy in their courses. The co-leaders also developed a solid working relationship that served as a model for other VCP members.

What challenges did we face and how did we address them? Only a limited number of participants were able to meet one another face-to-face at the ASEE Conference in Atlanta. Those who were there identified common areas of interest and pursued them outside of the normal meeting times. The others generally only were able to work effectively together through activities designed and led by the co-leaders. Because of this lack of group momentum, the co-leaders concluded that focused activities, like the ones that motivated their meetings each week, were necessary to achieve maximum engagement. Scheduling guests with clear expertise and experience of value to the VCP worked exceptionally well, but at the end of the Fall term no other participants had suggested any additional guests. It appears that there always has to be someone with the designated responsibility to organize activities for such a diverse group. Informal assessment was part of nearly all meetings, with the agendas for the last two Spring meetings generated almost entirely from participant ideas. Formal assessment was completed through the central VCP program at the end of the Fall 2013 semester, but results are not yet available.

## 5. Future Plans and Conclusions

What are our plans for sustaining the VCP? We anticipate continuing a regular meeting schedule in the Spring with more guests and two or three meetings to plan a workshop. There are two purposes for the workshop. First, it will provide an opportunity for all participants to finally meet one another in a traditional face-to-face context. Second, each participant will be asked to bring a colleague to expand the size of the group.

We conclude that our Circuits VCP provides a viable model for disseminating pedagogical innovations, for building community, and for establishing avenues of communication among geographically diverse participants. We draw six major conclusions from this experience:

1. **There is an acute need for advancement in engineering education and effective methods of dissemination.** The VCP was an effective way to disseminate the theory on research-based instructional practices (e.g., identifying and discussion relevant literature) and to share personal experiences. Even participants with a good deal of background and experience were able to fill in many holes in their knowledge.
2. **Current short-term, one-shot, face-to-face faculty workshops are inherently flawed and not scalable.** Five participants were able to attend face-to-face meeting at ASEE, compared to much higher attendance at virtual meetings. Cost of travel (and time commitment) present obstacles to attending face-to-face meetings.

3. **Learning communities and communities of practice offer an effective alternative**. In particular, *virtual* communities may be especially valuable for the many people who attempt to innovate in their classrooms with no local colleagues for support.
4. **Virtual approaches provide an effective, economical, and scalable approach without geographic constraints.** Essentially no one had any issues working across time zones or becoming enthusiastically engaged in discussions of all topics in engineering education.
5. **Engineering faculty will participate.** There was a fall-off in participation in the Fall, usually because the participants were tapped to take on additional administrative duties or their teaching skills were required for courses besides electric circuits. There were also participants who were dealing with family issues. With such a large group, the potential for conflicts is not small.
6. **Virtual communities can significantly expand external professional networks.** The majority of our community does not attend conferences like ASEE and FIE and, thus, they have limited opportunities to build a professional network to support their teaching and research. The Circuits VCP has helped all members find potential collaborators, mentors, etc.

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