121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #9892

Promoting Research-Based Instruction in Statics and Dynamics: A Virtual Community of Practice

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Abstract

Although research shows that instructional techniques such as active, collaborative, and inductive learning result in better conceptual understanding and improved student motivation, many of these practices are still not widely used in engineering education. Hour long workshops are not long enough to learn to effectively use these techniques, and do not seem to result in long-term adoption of these practices in the classroom. To help address this problem, five virtual communities of practice (VCP) were established to address topical areas as part of an NSF-funded project. One of these focused on Statics and Dynamics; 24 instructors from research-based, community colleges, and MS granting institutions participated in the Mechanics VCP.

The VCP was centered on aligning the classroom around teaching objectives, classroom activities, and assessment and utilized the How Learning Works framework for discussions. Topics included Bloom's taxonomy and writing learning objectives, active learning strategies, collaborative learning, conceptual understanding, hands-on activities, and flipping the classroom. An initial 8 week period introduced these topics and helped the instructors formulate their plans for the upcoming term, and a follow-on period is currently underway to help guide participants through this implementation. Participants reported benefiting from the weekly scheduled time to discuss teaching practices, learning about the different techniques, and especially hearing about what their peers are doing in the classroom. Challenges included logistical and technical issues, setting the proper scope of the VCP, and maintaining full participation and engagement of the community.

Introduction

The need for substantive changes in engineering education has been highlighted by a number of reports, including *Project Kaleidoscope*[10] and *The Engineer of 2020*. Although techniques such as active and inductive learning have been shown to promote better conceptual understanding, improve long-term retention, and increase student motivation[13], there are still a large number of faculty members who continue to favor "delivering content" using lecture-based approaches.

Most faculty development efforts tend to use the "develop-disseminate model" using short duration workshops. Although some of these efforts have had success[4], in most cases they do not result in widespread adoption[7]. Workshops and presentations at Frontiers in Education and the American Society for Engineering Education can help make faculty members aware of new practices in engineering education, but the participants in these programs are typically already engaged in pedagogical innovations. Survey data collected 6-12 months after four different workshops showed some success: 52% self-reported having looked over the workshop notes, 54% reviewed one or more related articles or websites, and 78% had implemented some variation of the approach[12].

The limited response rate (42% of the 114 participants) may have skewed the results somewhat, and again the number of overall participants using the one-time in-person model limits widespread adoption. In order to encourage widespread adoption of research-proven pedagogical approaches, longer term faculty development activities are necessary.

Communities of Practice

Some of the shortcomings of the one-time workshop model can be overcome through learning communities or communities of practice (CoP)[15]. In a CoP, participants work in a collaborative manner around common themes or goals. They are shaped by a *joint enterprise*, or domain of interest (in our case this is mechanics education) and depend on *mutual engagement* to help build relationships in the community. Finally, the CoP typically develops a *shared repertoire*, which might consist of communal resources and tools, shared activities and ideas, or different approaches to teaching. A sustained involvement in a CoP centered around faculty development allows participants to develop a sense of community, attempt new teaching practices and discuss implementation with other colleagues, and share different teaching resources.

One successful implementation of a community of practice built around developing a student-centered approach was conducted at a large, four-year university. Participants began by attending a four-day workshop, and then met in bi-weekly group meetings. Initially, participants (especially in STEM fields) were concerned about class time, covering enough content, and implementation difficulties. As the CoP progressed, faculty developed "a better understanding of the concepts and how they can be utilized effectively in the classroom" as reported by one of the participants[6]. Many other universities have implemented multi-disciplinary learning communities around topics such as active learning, flipping the classroom, and online teaching.

While these larger, multidisciplinary learning communities have many benefits, many issues favor smaller, more focused cohorts. Engineering professors often have different goals/expectations, experiences with technology, and teaching constraints than those in other disciplines. Faculty may desire specific, concrete examples of how to apply different research-based practices in the courses they teach, rather than becoming an engineering education researcher themselves. At many universities, there may only be a handful of professors who teach the same course, which makes forming a CoP problematic. To solve this problem, we have developed *Virtual Community of Practice (VCP),* where participation is web-based.

Virtual Communities of Practice

A VCP offers several benefits over in-person workshops or longer term learning communities at a single institution. In order to have widespread impact in the engineering education community, it is imperative to reach a large number of different institutions. Internet tools enable faculty to participate from a variety of geographical locations, allow easy recording of synchronous meetings for later dissemination, and are extremely cost-effective[8, 14].

A successful implementation of a VCP involved 20 participants at 10 universities; each university had pairs of faculty members, one from engineering and another from a different STEM field (participants were provided an honorarium). Participants met in person first, and then had weekly online discussions. Project goals were to help faculty (quote[3]):

1) engage in reflection and continuous improvement of learning, both their own and their students
2) facilitate conversations about teaching and learning in the process of building a learning community
3) create a collaborative learning environment with faculty and peers
4) build confidence in curriculum development including designing, guiding, and assessing learning
5) learn with and about technology in the process of improving curriculum, and
6) connect teaching and research and bridge the gap between theory and practice.

Recognizing the potential for widespread engagement of engineering educators, an initiative on Advancing Engineering Education through Virtual Communities of Practice (NSF grant DUE-1224217), funded five different VCPs in engineering in the spring of 2013[9,11]; the Mechanics VCP was one of these.

Mechanics Virtual Community of Practice

Recruitment for the VCPs was done by contacting ASEE members, NSF awardees, engineering deans, and department heads. Purposeful effort was made to contact faculty at minority serving intuitions. Twenty-six participants (18 male, 8 female; 3 Asian; 1 Black or African American; 1 Hawaiian or Other Pacific Islander) were originally selected for the VCP; two chose to drop out before the sessions began. Mechanics VCP members captured a range of attributes of both individuals and institutions, including:

- teaching commitments each semester (ranging from 1 to 5 classes),
- class size (ranging from 3 up to several hundred),
- student profile (ranging from traditional, college-aged students to students who are non-traditional in a variety of ways),
- course delivery approaches (ranging from all face-to-face to some fully online delivery),

- appointment types and career stage (ranging from new PhDs on the tenure track to tenured faculty to non-tenure-track appointments at various ranks),
- institution type (public/private four-year, community college),
- research responsibilities (ranging from essentially none to fairly intense research expectations),
- institutional postures/rewards systems with respect to teaching (ranging from undergraduate teaching being the institution's primary mission to undergraduate teaching being one mission within the context of a research university), and
- institutional expectations about education-related professional development (ranging from a definite expectation of continued development to no discernable expectation of continued development).

This diversity contributed strongly to the identity of the group, and each brought a particular perspective to the community in terms of values, needs, and expectations about mechanics education.

Each of the applicants to the VCP was required to: 1) obtain a recommendation from his or her dean/department head; 2) be scheduled to teach an introductory course in Fall 2013; and 3) provide informed consent to use online meeting data, asynchronous collaboration data, and survey data.

Participants had a wide range of experience with using different research-based practices, as shown in Figure 1.

Despite this wide variation in experience, many had similar issues they were hoping to address. For instance, many community members expressed concern about their D/F/W rate in mechanics courses (the percentage of students who either withdraw from the course, or complete it with a grade of D or F). Mechanics VCP members indicated a broad interest in using active learning techniques to combat D/F/W rates, and the survey results of Figure 2 emphasize that diversity of educational environments and experiences reported by Mechanics VCP members.

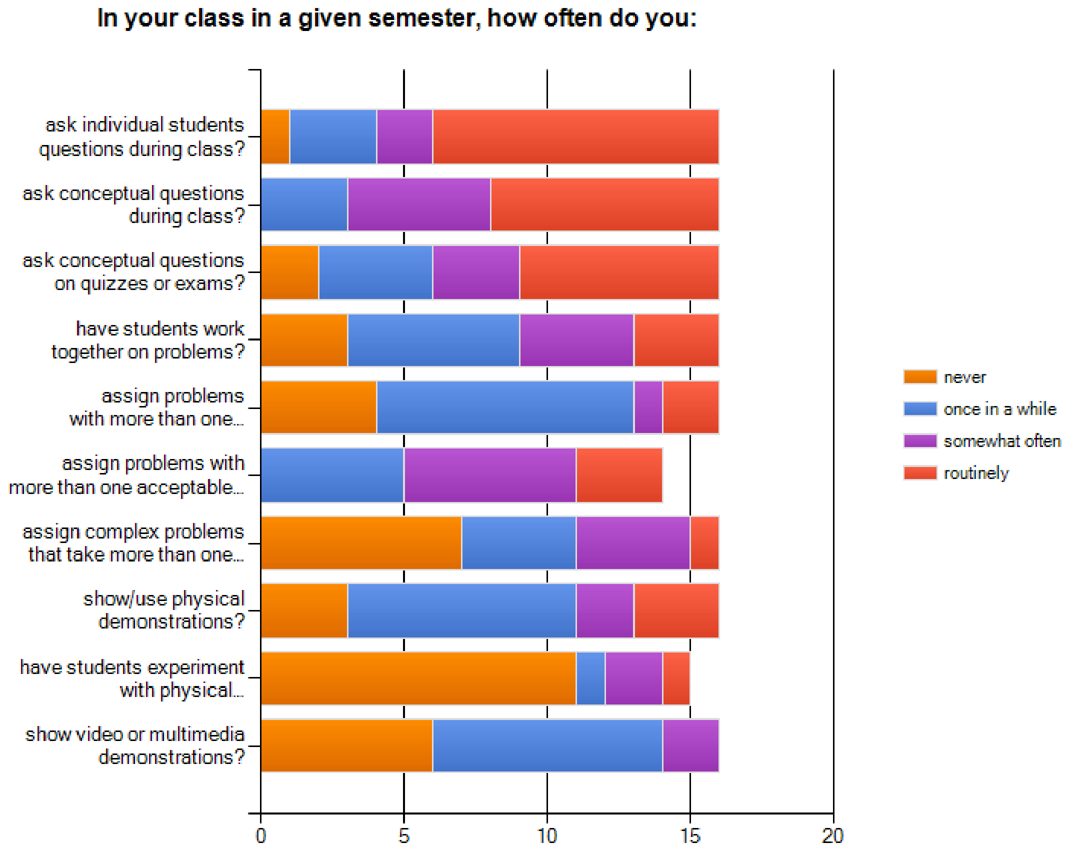

Figure 1. Mechanics VCP use of different pedagogical practices.

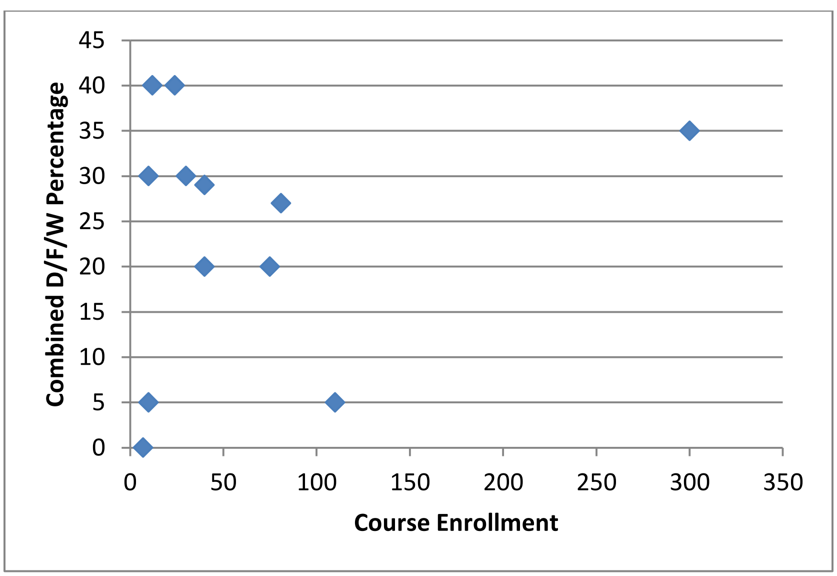

Figure 2. Mechanics VCP reported D/F/W rates by course enrollment (n = 12).

Mechanics VCP Resources

The VCP held weekly synchronous, online ("virtual") meetings using Adobe® Connect™ (Adobe Systems, San Jose, CA). This conferencing platform is similar to others (e.g., WebCT, Blackboard Collaborate) and provides a whiteboard, desktop and resource sharing (including MS PowerPoint presentations), group and private chat, and shared notes. Many of the participants made use of the chat feature to further discussions on topics of interest, provide websites, and to ask questions. A screen capture of a typical session is shown in Figure 3.

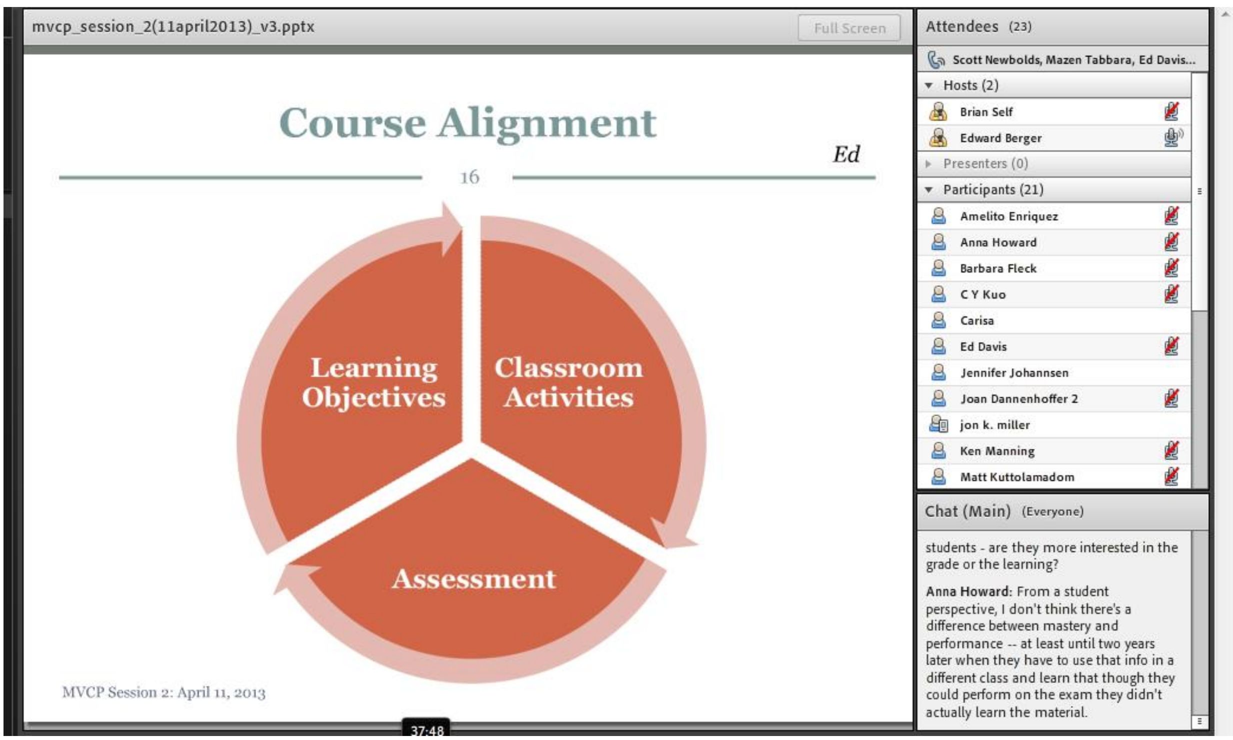

Figure 3. Screen shot of Adobe Connect synchronous VCP session.

One useful component of the software was the ability to hold breakout sessions. This allowed us to form smaller groups that could discuss different topics of interest. The VCP could then reconvene and report out what they discussed in their individual groups. An example of a breakout prompt and resulting breakout room notes (that were shared with all participants) is provided in Figure 4.

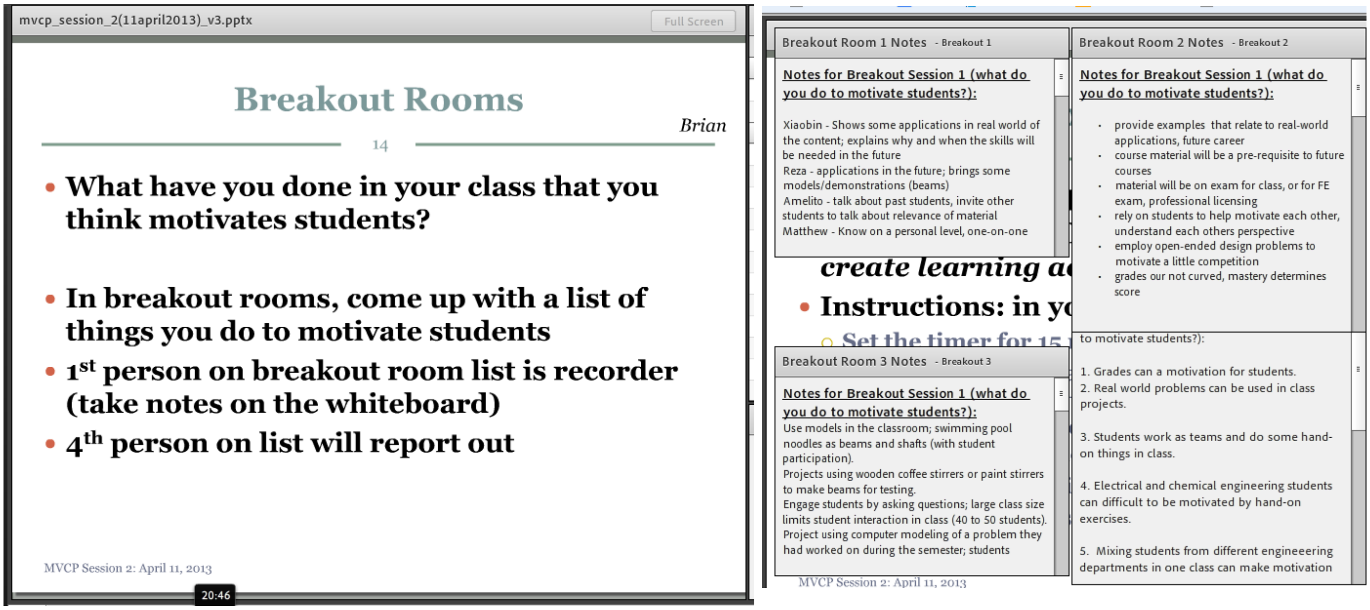

Figure 4. Adobe Connect breakout room prompt and resulting notes.

Open Atrium 1.0, (Phase2 Technology, 2011) was used for asynchronous communication between weekly virtual meetings. This was primarily used as a repository for shared resources, including weekly slides, references on teaching and learning, and recordings of the weekly meetings. We also used folders in the Portal so that participants could upload different assignments, including example syllabi, concept questions, and teaching goals. A screen shot of the portal is shown in Figure 5.

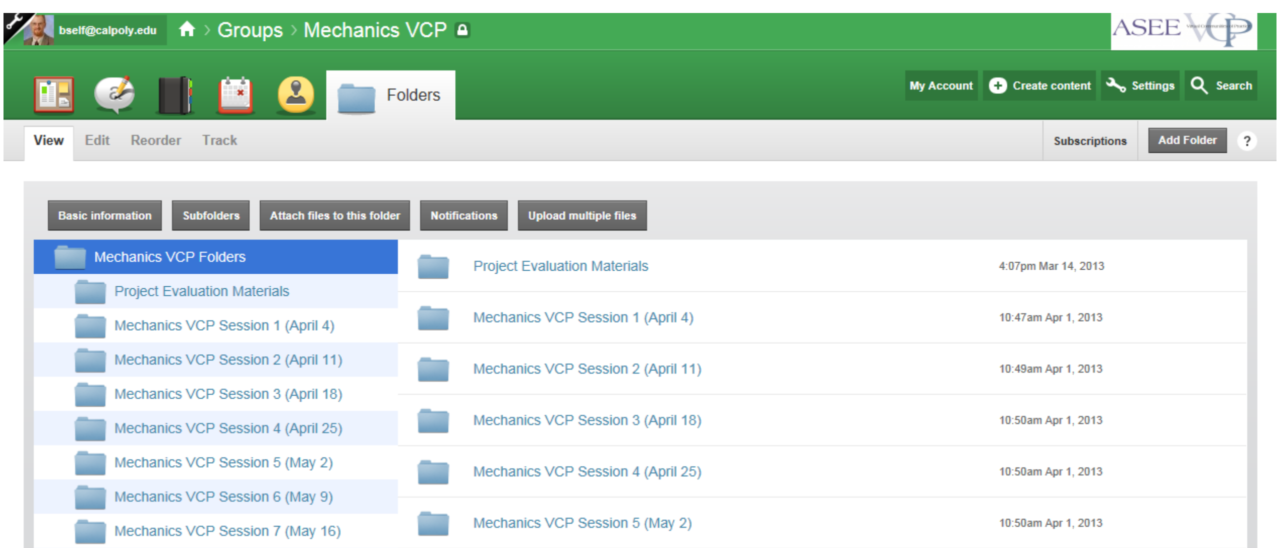

Figure 5. Open Atrium asynchronous portal.

An additional feature of the portal was the use of blogs. The authors would often post different questions or topics of interest to the group, and then monitor the resulting discussion. Several participants also began discussions on their own.

Principles Used in the VCP

The leaders of each disciplinary VCP met in a ten-week Leadership VCP (L-VCP) to assist in organization, content, and planning. The L-VCP applied guidelines for engineering faculty development established by Felder and his colleagues, and encouraged the leaders of each disciplinary VCP to do the same. Felder's group has used these guidelines in their highly successful National Effective Teaching Institute (NETI) workshops[2, 4, 5]:

1) use facilitators with expertise in both engineering and pedagogy
2) use engineering-related examples and demonstrations
3) target content to the needs and interests of the participants
4) provide choices in applications of recommended methods
5) model recommended techniques
6) provide opportunities for formulating and practicing their own applications
7) actively engage participants

Additionally, we used the framework established by Ambrose et al in *How Learning Works*[1]. Their seven research-based principals for quality teaching and learning are (quote):

1) Students' prior knowledge can help or hinder learning.
2) How students organize knowledge influences how they learn and apply what they know.
3) Students' motivation determines, directs, and sustains what they do to learn.
4) To develop mastery, students must acquire component skills, practice integrating them, and know when to apply what they have learned.
5) Goal-directed practice coupled with targeted feedback enhances the quality of student' learning.
6) Students' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning.
7) To become self-directed learners, students must learn to monitor and adjust their approaches to learning.

This framework, along with the over-riding principle of aligning course objectives, classroom activities, and assessment, was the basis upon which we developed the Mechanics VCP. The agenda and schedule for the VCP are shown below.

Mechanics VCP Schedule and Agenda

1. Understanding Student Motivation and Engagement in the Classroom, April 4, 2013
    - Mechanics VCP learning objectives
    - Objectives for today's session
    - Quick technology shakedown
    - Overview of the How Learning Works (HLW) framework
    - Promoting a positive classroom climate
    - Structuring learning to mesh with student motivation
    - Foreshadowing: learning taxonomies (Session 2)

2. Student Motivation and Learning Taxonomies, April 11, 2013
    - Objectives for today's session
    - Review of your feedback from Session 1
    - Structuring learning to mesh with student motivation
    - Learning taxonomies
    - Assignments for Session 3 (18 April 2013)

3. Aligning Learning Objectives, Activities, and Assessment, April 18, 2013
    - Objectives for today's session
    - Review of D/F/W survey and blog comments
    - Structuring classroom activities and assessment to match learning objectives
    - Assignments for Session 4 (25 April 2013)

4. Using Active Learning Techniques to Align Objectives, Activities, and Assessment, April 25, 2013
    - Objectives for today's session
    - Structuring classroom activities and assessment to match learning objectives
    - Active learning examples, including your own concept questions
    - Assignments for Session 5 (2 May 2013)

5. Project-Based and Team-Based Learning Activities, May 2, 2013
    - Objectives for today's session
    - Review of your blog posts
    - Project-based and team-based learning strategies
    - Assignments for Session 6 (9 May 2013)

6. Using Hands-On Demos and Flipping the Classroom, May 9, 2013
    - Objectives for today's session
    - Flipping the classroom
    - Now you have time for some interesting hands-on demonstrations and activities!
    - Assignments for Session 7 (16 May 2013)

7. Steps Forward, Educational Research, Writing Grants and Papers, May 16, 2013
    - Objectives for today's session
    - Next Fall – schedule and your goals
    - Educational research and assessment
    - Writing grants and papers

Assessment of the Mechanics VCP

A satisfaction survey was used to determine interest in and satisfaction with the Mechanics VCP. Participants rated:

1) the level of content (from 1-Too Easy to 5-Too Advanced)
2) the pace of the sessions (from 1-Too Slow to 3-Too Fast)
3) the workload (from 1-Rather Light to 3-Too Much)

Participants also used a Likert-type scale, from 1 (Strongly Disagree) to 5 (Strongly Agree), to rate their level of agreement with the following statements:

1) The on-line technology was easy to use (Technology-Ease)
2) The on-line technology facilitated collaboration (Technology-Collaboration)
3) Activities during on-line sessions were useful (Synchronous-Usefulness)
4) Activities outside on-line sessions were useful (Asynchronous-Usefulness).

Table 1. Mechanics VCP survey responses

Item	Scale	Responses (n = 17)
		M (SD)
Level of Content	1 (Too Easy) - 5 (Too Advanced)	2.71 (0.69)
Pace	1 (Too Slow) - 3 (Too Fast)	1.82 (0.53)
Workload	1 (Rather Light) - 3 (Too Much)	2.18 (0.53)
Technology – Ease	1 (Strongly Disagree) – 5 (Strongly Agree)	4.29 (0.92)
Technology – Collaboration		3.76 (1.09)
Synchronous – Usefulness		3.82 (1.07)
Asynchronous – Usefulness		3.53 (0.62)

A second survey was given to evaluate awareness of, attitudes towards, and adoption of research-based instructional approaches. Participants used a modified Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree) to rate agreement with 20 different statements. Four survey items assessed the awareness stage (e.g., “I am aware of the ‘think-pair-share’ teaching strategy”). Seven items assessed the attitudes and interest stages, the ‘Attitudes’ subscale (e.g., “A goal of instruction should be to change students’ conceptions”). Nine items assessed the evaluation and adoption stages, the ‘Adoption’ subscale (e.g., “In my classes students often work on group projects”). Responses are provided in Table 2.

Table 2. Responses on Research Based Instructional approaches survey

	Pre-Baseline			Mid-Point		
	Awareness	Attitudes	Adoption	Awareness	Attitudes	Adoption
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Mechanics (*n* = 19)	3.70 (0.45)	3.74 (0.41)	3.88 (0.35)	3.95 (0.38)	3.82 (0.28)	3.94 (0.38)

Finally, some measure of success can be provided by analyzing the number of participants during each of the sessions, as shown in Table 3.

Table 3. Number of participants each session.

	Session 1 *n* (%)	Session 2 *n* (%)	Session 3 *n* (%)	Session 4 *n* (%)	Session 5 *n* (%)	Session 6 *n* (%)	Session 7 *n* (%)
Mechanics (*n* = 26)	24 (92.3%)	22 (84.6%)	17 (65.4%)	18 (69.2%)	14 (53.8%)	16 (61.5%)	16 (61.5%)

Discussion

The first implementation of the Mechanics VCP went reasonably well. There were a few technological glitches, but in general participants were able to log in to the synchronous sessions and get their microphones and audio working (or at least use the chat feature to participate in discussions). Faculty enjoyed sharing what they were doing in their classrooms, and hearing what others were doing in theirs.

In general, participants thought that the level of content, pace, and the amount of workload were appropriate. The participants “agreed” that the online technology was easy to use and helped to facilitate collaboration. The synchronous activities were more helpful than the asynchronous activities (of which we did not take full advantage). The results from the Research Based Instructional approaches survey only showed modest improvements in awareness of, attitudes towards, and adoption of research-based instructional approaches. Because this survey was taken at the end of the spring 2013 term, participants may not have had time to incorporate new techniques in their classrooms yet.

The attendance figures in Table 3 do suggest some broader issues related to these kinds of professional development activities. There certainly was a core group of reliable attendees, a second group of occasional attendees, and a very small group of truly infrequent attendees. The reliable attendees were highly motivated to both learn and share, as evidenced by their participation in discussions, their enthusiasm for learning new techniques, and their thirst for networking among the VCP participants. This group highlights an important feature of CoPs that distinguishes it from other professional development activities such as workshops: the responsibility of the attendees to share their wisdom, rather than simply learning something new. Anecdotally, these are the moments when the Mechanics VCP functioned at its best: when the attendees were enthused about sharing with each other, about comparing experiences, successes, and failures, and about enjoying the solidarity of our shared passions and struggles in engineering education. This lesson is not to be overstated. Community leadership is important in terms of setting directions and moderating discussions, but a highly-motivated group of attendees is what separates a successful VCP from a failed one.

The occasional attendees often alerted the VCP leaders that they could not attend, and typically the reasons were the perfectly-reasonable, usual faculty commitments: meetings or travel. So there were excellent intentions even among the occasional attendees, but logistics prevented them from being in the reliable group.

The diversity of institutions and faculty appointment types represented in the VCP members was a great strength of the program, sometimes in unexpected ways. On one hand, having great diversity of educational environment but sharing a similar interest (say, the D/F/W issue presented above) allows for wide-ranging discussions about potentially useful active-learning strategies that work in small classes or large. On the other hand, there were occasional foci and discussions on issues quite specific to one member's situation that, at first glance, might not appear to have broad applicability within the group. For instance, sometimes there are tools or techniques that work very well in small enrollment classes that do not appear to transfer effectively to large classes. But within the Mechanics VCP group, we were often able to generate ideas of how those techniques could be slightly altered to make them more useful in large enrollment settings. There were many instances in which the combined intellect, passion, and especially diversity of experiences of the group were instrumental in defining specific ideas and actions of more general applicability to the group.

As with any other community-oriented initiatives, *engagement* and *value* seemed to have been the key drivers in participation and should be explicitly built in to the structure of the community synchronous meetings and asynchronous activities (and the advertisement for participants). Engagement clearly requires members to want to be involved, to enjoy sharing and networking with their peers, and to (to the extent possible) prioritize VCP gatherings over other possible uses of their time. We promoted engagement in the virtual meetings by encouraging members to introduce themselves, present brief overviews of their work and ideas, team together in break-out sessions to discuss topics of common interest, and take over leadership roles within the group.

Value is the other key component, and delivering value to VCP members means giving them concrete, implementable strategies that they can deploy in their classrooms with a minimum of overhead. We promoted value by framing the entire VCP around the How Learning Works ideas (which themselves are derived from a meta-analysis of the research literature on teaching and learning), by continually emphasizing the use of small, reasonable steps in making changes to teaching approaches, by constantly exposing the linkages within the triad of outcomes-activities-assessments, and by generally coaching and mentoring the VCP members toward more active pedagogies in support of their instructional goals. Feedback from the members also reinforced the fact that the networking function of the VCP imparted value. The survey results, including attendance data, substantiate the idea that the Mechanics VCP held value for the participants.

As with any new workshop or course, future iterations could certainly be improved. Perhaps the most important alteration would be to extend the formal period of the VCP to explicitly include the members' integration of active learning strategies in their courses, and the assessment thereof. As it stands, members are in the midst of making some changes (some were made in Fall 2013, others are planned for Spring 2014), but the project simply did not have adequate funding to fully close the loop on this process and examine changes in course-related metrics like course evaluations, D/F/W rates, improvements in achievement of specific learning outcomes in the course, etc. Given the time demands placed on all faculty members, it would have been very useful if the project could fund an initial round of assessment for each individual VCP member to make a preliminary assessment of how their participation in the Mechanics VCP impacted the teaching and learning in their classrooms.

Nonetheless, the initial implementation of the Mechanics VCP had many merits and seems to have added value to the professional development of many of the VCP members. We expect to report further on the Fall 2013 VCP activities (which were less formalized than the Spring 2013 activities) in a future ASEE paper.

Acknowledgments:

This material is based upon work supported by the National Science Foundation (NSF) under Grant No. DUE-1224217. Any opinions, findings, interpretations, conclusions or recommendations expressed in this material are those of its authors and do not represent the views of the ASEE Board of Directors, ASEE's membership or the National Science Foundation.

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