CALSTEP Evaluation Report, Spring 2017

This document presents an assessment of progress achieved by CALSTEP between July 1, 2016 and June 30, 2017.   The report is based on data and other information gathered from surveys and interviews with students enrolled in courses using CALSTEP curriculum and other resources; interviews with the CALSTEP instructional team and with other faculty using CALSTEP curriculum and resources; surveys of faculty members who are or may be interested in using CALSTEP curriculum and resources; and an analysis of enrollment and outcome data.

The information and findings are organized around six research questions:

1. What progress has been made in developing and testing CALSTEP curriculum and resources?
2. What progress has been made in testing alternative instructional modes of delivery?
3. What progress has been made in disseminating CALSTEP resources?
4. Did students in courses using alternative delivery strategies enjoy higher course enrollment, success and persistence rates than students in traditional lecture style courses?
5. What impact has CALSTEP had on transfer?
6. What major lessons have been learned thus far and what are the next steps?

1. What progress has been made in developing and testing CALSTEP curriculum and resources?

The CALSTEP model is that one instructor develops new curriculum and tests it in his own classroom. The curriculum and other resources required to deliver the course, including special instructional strategies, are then tested by other members of the CALSTEP instructional team. After the second or third iteration, the curriculum and other resources are offered to additional instructors and presented at the annual Summer Engineering Teaching Institute and the Engineering Liaison Council. In addition, resources are posted on the CALSTEP website: http://canadacollege.edu/nsf-iuse/curriculum.php

Progress achieved during the past grant period included:

a. Testing of lab curriculum activities, including online assignments for students in **Introduction to Engineering** at Skyline College with additional testing at College of San Mateo and Monterey Peninsula College (MPC);
b. Continued testing and development of online lab curriculum for **Engineering Graphics** at Cañada College and replication at College of San Mateo;
c. Second run of **Materials Science** at MPC and continued testing and development of Materials Science curriculum and resources at College of Marin (COM);
d. Continued testing and development of online lab curriculum and additional resources for **Circuits** at MPC with additional testing at at COM

The following discussion presents key findings from qualitative research conducted to collect student and faculty perspectives on the implementation of these new, improved and replicated CALSTEP curriculum and resources:

a) CALSTEP's addition of labs to the **Introduction to Engineering** course, including those enrolled online, provides students with much needed opportunities to conduct experiments where they see how math and physics is applied in engineering. This opportunity addresses what often represents a major barrier to persistence in engineering both at community and four-year colleges where students have to complete a long sequence of challenging advanced math and physics courses before they have opportunities to design or build anything. In other words, it can require years – especially for students who come from under-resourced high schools – to work their way through abstract and foundational courses before they have the opportunity to apply math and physics to engineering problems and projects. The new Introduction to Engineering course breaks this pattern and, like the NSF-funded Math for Engineering at Wright University, provides students with opportunities to immerse themselves in hands-on activities from the get-go. In a survey conducted at the conclusion of the course that asked students to identify the course component or experience that had the greatest impact on increasing their understanding of what it means to be an engineer, the two top-rated activities were the lab projects (Arduino design and MATLAB coding). One student noted:

"The [Arduino Robot Roaming with Whiskers] offered hands on involvement where you could control and manipulate different things in the lab. It was the most valuable [course activity] as it increased my interest in engineering."

In response to a question about how to strengthen the course, one student noted:

"Have more labs, if its possible. But I feel like the labs are great already, although I would like to see more of each of them. To go more in depth into each lab, like more background knowledge and what more details mean so we can better understand the big picture."

b) In Fall 2015, **Engineering Graphics** was offered online and face-to-face by two different instructors. Students in the online section on the average performed better in tests than students in the F2F section. The differences were not statistically significant except for one test question on one particular topic (Sectional Views). In surveys, it was also found that satisfaction with the course experience was greatest among the online students. However, it should be noted that the instructor who taught the online Engineering Graphics course – also the CALSTEP PI-- developed the curriculum; has more than a decade of experience teaching online; is considered one of the most experienced and effective online engineering instructors in California; and conceived of and secured funding for Summer Engineering Teaching Institute (SETI), the professional development session that helps engineering instructors from around California integrate technology into their classrooms. This instructor is also a student favorite and always receives very high ratings from students online as well as FTF. The F2F instructor was an adjunct and relatively new to teaching.

In Fall 2016, a better comparison was possible between online and FTF delivery of Engineering Graphics when the same instructor – the CALSTEP PI – taught both the online and FTF version of the course.

In surveys, the Fall 2016 Engineering Graphics course online students (11) identified as the most effective resources that helped them understand class material and completing

assignments "emailing questions to the instructor " while the FTF students (18) pointed to "in-class lectures" as the most effective resources. Interestingly, both online and FTF students gave high ratings in terms of effectiveness to emailing and requesting help from other students. This suggests that it is possible to create a community of learners among online students.

Surveys also found that FTF students were more likely to "strongly agree" that they felt there was a strong connection between the course lecture and lab components and that they had sufficient guidance to do the labs. The FTF students were also slightly more likely to understand the learning objectives for the lab both before starting the lab activity and after completing the assignment. These findings represent a reversal of the finding from the Fall 2015 surveys. A possible explanation is that the overall learning experience for FTF students tends to be better for FTF than for online students, even when the instructor is excellent and highly experienced in online delivery.

Nevertheless, the overall satisfaction with the course among the online students was very high when they were asked to compare this to other online courses they had taken. An overwhelming majority of the online participants thus felt the course was "very effective" or "effective" compared to other online courses they had taken in the past.

Also interesting, in many of the other courses with online options CALSTEP surveys have found that online students spend longer than their FTF peers on courses, and especially on course lab assignments. This was not the case with Engineering Graphics where the time spent varied widely among all students. For online students the average was 8.9 hours/week with a range of 5 hours – 16 hours while for FTF students, the average was 9.5 hours per week with a range of 3-25 hours.

c) In Fall 2015, the **Materials** curriculum piloted at College of Marin was replicated at Monterey Peninsula College. As described in previous reports, both students and the instructor and assistant instructor struggled their way through the MPC course for a number of different reasons. It was the first time the MPC instructor had taught Materials and he only ended up doing so because a colleague originally scheduled to teach the course was unable to do so. Rather than leaving students who depended on the course for transfer stranded, the MPC faculty member decided to move forward with Materials. With MPC lacking the lab facilities for Materials, an all-day lab experience was scheduled at CALSTEP partner college Canada. This experience, according to a survey conducted at the end of the semester, proved the students absolute favorite course activity. However, satisfaction with the overall learning experience in the course was much weaker with many students expressing frustration about how confused they had been in the course and with more than 70% of students stating they would not recommend the course to others.

In Fall 2016, using feedback from student surveys and interviews and collaborating with the COM CALSTEP faculty member who designed the course, MPC offered the course a second time.   Improvements included increased consistency in video presentations so that more than 80% of the roughly 150 videos in the course were delivered by two presenters. Additionally, some of the longer lessons were broken down into two shorter lessons, resulting in all lessons having total durations of 45 to 60 minutes (or 30 to 40 minutes at the students' anecdotally preferred playback speed of 1.5x). In order to more closely guide student learning, the problem

sets were rewritten with the intention to be completed while watching the lessons, explicitly correlating each video in the lesson with several problems intended to emphasize the key learning objectives of that video.

Efforts were also made to improve the lab experience and to address obstacles students identified to learning in Fall 2015, including difficulties understanding and manipulating the COM EXCEL spreadsheets that were used to deliver a virtual lab experience. In Fall 2016, student perceptions of the lab component of the course improved relative to the year before, although showing a considerably lower level of satisfaction than the COM students. Part of the reason is likely the difficulty MPC is experiencing substituting the actual for a virtual lab experience. Since the hope is to have additional and especially smaller colleges use the curriculum— including institutions that very likely will not have Materials lab facilities – the CALSTEP team will continue efforts to improve the virtual lab experience.

d)   Ongoing assessment and improvement continued with the **Circuits** course lecture and lab components, offered again at Monterey Peninsula College (MPC) where it was first developed. Components of the course were also incorporated in Circuits course lecture and lab offered at COM using the Emporium model (see below). In surveys MPC online students (5 among 22 survey completers) assigned a higher value than their hybrid and FTF peers to their rating of how helpful lab videos were in helping them complete lab assignments.

The "lab videos featuring instructor demonstration" resource was useful to me because it allowed me to experience the lab the same way as the in-person students.

Overall, all survey respondents agreed that the written lab instructions were the most helpful resource. One student noted:

The written laboratory instructions resource was useful to me because it gave clear and specific steps to complete the lab.

In terms of resources provided to support completion of homework, quizzes and exams, online students gave the highest rating to "watching video lectures (4.8 out of 5) while FTF and hybrid students felt that the review quizzes were most helpful.

There was no major difference between how strongly online and FTF students felt the classroom and lab activities were connected (on a scale from 1-5 their average ratings were 4.4 and 4.5 respectively). However, online students assessed their confidence in working electronics hardware and equipment resulting from the lab at 3.8 compared to FTF students' 4.7.

Note that the sample sizes are small so the survey findings should be considered within this context.

There was agreement in written responses that one of the best things about the course was the opportunity for hands-on applications as offered by the lab. One student commented:

I enjoyed building the circuits with my hands, since it's been the only class .. I've taken where I felt like I was "engineering".

2. What progress has been made in the testing of alternative instructional modes of delivery?

During the year experimentation with alternative modes of instruction continued among CALSTEP team members. At the same time, additional instructors began to introduce CALSTEP curriculum and technology in their courses.

Considerable experimentation was conducted with different kinds of **video delivery** and with the incorporation of a wide range of tools that students could use to maximize learning while watching videos.   Additional experimentation helped CALSTEP members learn more about how to support team work assignments in online courses, including labs.

In surveys conducted at the conclusion of each semester, students were asked what they do when watching videos. For example, do they stop and repeat things they don't understand; write down questions; email other students or the professor with questions; watch at an accelerated speed; and do they get sidetracked checking email, text messages or by other types of distractions.

Across the CALSTEP courses, a large majority of students are most likely to watch at an accelerated speed, scrolling back to repeat things they don't understand. Another common finding from CALSTEP surveys is that many students are not in the habit of writing down questions they have while watching videos, or asking for help.

Students were also asked which resources they consulted most often and found to be most helpful. Additional questions asked for feedback on different types of video delivery.

Overall, key findings across CALSTEP courses point to the fact that many students struggle watching videos on their own; almost always watch at an accelerated speed, returning to material they do not understand to watch this several times. Students prefer short videos and always want as much labeling as possible to make it fast and easy to find in a recording specific information or lecture segments. They do not like to have multiple instructors deliver the videos, preferring instead to have most or all videos feature their classroom or online instructor. In addition to failing to record questions, many students also report that they do not take notes while watching video.

There are many approaches instructors can take to enhance students' video watching experience and the CALSTEP team has learned and applied many of these lessons to develop and refine ever more effective videos and to supplement there with resources that help students become effective users of videos and other online instructional tools.

The experimentation with course flipping also continues with some CALSTEP courses being delivered partially flipped and others fully flipped. The student response to flipping has been overwhelmingly positive with most surveys finding that a majority of students would take more flipped courses given the opportunity. Even more importantly, CALSTEP surveys consistently find that students in flipped courses feel the active delivery format is transforming them into

more engaged learners. In interviews, it should be noted, several students who have completed flipped courses underscored that to be successful in this kind of learning environment, you have to be willing to ask questions in class and learn "*how to feel okay*" solving problems on the board in front of your peers.

One part of the flipping experimentation this past year involved the first delivery of Emporium-style courses at College of Marin (COM). During the Fall 2016 semester, Statics and Circuits were co-scheduled and delivered by one instructor who divided his time between students in the two courses.   With three students in Statics and two students in Circuits, the co-scheduling enabled the small Engineering Department at COM to offer during the same semester two courses that students need to transfer and/or to strengthen their transfer applications.   In Spring 2017, four courses were offered at COM in the Emporium format. They included co-scheduled MATLAB and Materials and co-scheduled Circuits and Statics courses.

The Emporium-style courses are basically flipped courses where students assume a great deal of responsibility for their own learning as the instructor is only available approximately half of the time. In this format, students spend the entire class working in teams to solve problems. One instructor explained: *"It is active learning all the time. They are at the board or waiting for their turn."*

The instructors were asked about whether certain courses are more suited for this mode of delivery and also about what combination of courses work well. In the first iteration the instructor noted that Statics worked better than Circuits. However, the reason may have been that Statics was highly structured from the outset and grounded in curriculum from a tried and tested online course. In the Fall 2016 Circuits courses, the instructor noted that "*students began to do better in Circuits when [the instructor] provided them with day-by-day instructions on what they needed to do and students realized they had to keep up."*

The Spring 2017 testing of Emporium delivery went well from both the instructors and students' perspectives. MATLAB had an enrollment of 12 students, the highest number of Emporium-style course participants to date. The instructor felt that this course lends itself well to the Emporium format although there is some risk of students getting stuck on a problem and not being able to get help until the instructor returns from the other classroom – in this case the Materials course next door where, especially during labs, the instructor felt he had to be present most of the time. The need for the instructor to move from one class to the other was mitigated in both Fall 2016 and Spring 2017 by the fact that the co-scheduled courses were offered in adjacent classrooms. The downside of this was that the MATLAB instruction took place in a regular classroom instead of in a computer lab.

While there are logistics to be addressed for those planning to offer Emporium courses, there are several other considerations that the Emporium-piloting CALSTEP instructors and students identified:

- Students and faculty both recommended that only highly engaged students who are or can quickly become comfortable asking questions and working in teams should consider taking Emporium style classes.   As pointed out by Emporium students in interviews:
  - ✓ *"At first [working on the board and making mistakes in front of other students] ..was nerve-wrecking. Then later, we were laughing a lot and it was okay to make errors."*

- ✓ *"It was a unique experience – like running a class with our classmates."*
- ✓ *"Only take an Emporium-style course if you are serious and if you like working with others.*"

- To teach Emporium style, the instructor has to be flexible and comfortable improvising. It is a total departure from lecture-style. Both Emporium instructors underscored that only instructors with considerable experience teaching the two courses that are offered Emporium style should consider this delivery format. "You have to be completely confident that you can come into the classroom at any moment and immediately figure out what is going on. " In other words, only instructors with considerable experience delivering flipped courses and with teaching the courses included in the Emporium offering should consider this mode of instruction.
- If these conditions can be met, the benefits can be considerable. Since students are problem-solving all the time, the instructor can customize his/her teaching to match the type of learners enrolled. Things move along at the students' pace - the opposite of lecture-style where the instructor sets the pace. In an end of semester survey, Circuits students rated different course activities in terms of when they felt they learned the most, assigning an average rating of 4.5 (on a scale where "1" was learned the least and "5" learned the most) to "when working on problems in class" compared to an average rating of "2" to "time spent reading the text book." The sample here is very small (n=4), but the finding certainly points to the need for additional research into the potential benefits that can be achieved by exposing students to this kind of learning environment.
- The Emporium-style students were also for the most part very satisfied with the learning experience. In the Emporium-style Circuits courses, three of four students said that the flipped instructional format made them more engaged learners. "*This is an exciting way to take the class*," one student commented.

One concern that the team will consider during the next year is whether students in Emporium-style courses are learning the theory behind the problem-solving. As one instructor noted: "The danger is that they are just working through the problems. Some of the theory, you cannot test for with problem-solving alone."

3. What progress has been made in the dissemination of CALSTEP resources?

During the past year, faculty from Skyline College joined the original CALSTEP team to expand the core group of CALSTEP colleges from three to four. The addition of Skyline College was especially significant since this college did not in the past have an engineering department and has now established as a priority development of STEM learning communities.

Dissemination to a wider array of colleges included presentations and outreach at the bi-annual Engineering Liaison Council, development of the CALSTEP website which now features a wide selection of CALSTEP curriculum and resources, and hosting of SETI two-day workshops in the summer of 2016 and 2017.

A survey of SETI 2017 participants conducted prior to the training found that the incoming group of ten faculty members had no or very limited experience teaching in an online format and teaching flipped courses. Similarly, a majority of participants had no or very limited experience creating instructional videos. A focus group was conducted at the conclusion of SETI 2017

where participants expressed great excitement about putting the new technologies to use in their classrooms. One participant noted he plans to produce curriculum to use online and make his courses more interactive. Another participant plans to develop and present to her dean a brief presentation on the SETI resources and instructional methods. Other members of the SETI 2017 cohort agreed that a first step at their college is to get administrators on board and enthusiastic about the way that technology and alternative instructional formats can increase engagement and improve student outcomes.

SETI participants also identified as a high priority the opportunity to continue the conversations and collaboration that was launched during the two-day session. Among the possibilities considered was follow-up webinars to provide participants with a venue to compare notes about how their integration of SETI-resources and technologies are working. Advice from past SETI participants was shared, including suggestions that participants start developing video content during the summer.

In addition to disseminating CALSTEP resources to faculty at other California community colleges, the CALSTEP team shared approaches pursued and findings generated at ASEE and other conferences.   Overall, the team presented and published eight papers between 2015 and 2017.

4. Did students in courses using alternative delivery strategies enjoy higher course success and persistence rates than students in traditional lecture style courses?

Students who enrolled in courses using alternative delivery strategies including online or flipped classroom methods, on average had lower course success rates than students who enrolled in traditional face-to-face courses (75% vs. 83%, respectively, see Table 1). This result should be interpreted with caution since the course materials continue to be modified as new instructors adapt the materials. In addition, instructor variability may also contribute to the differences in outcomes. For example, the course with the lowest course success rate was a face-to-face graphics course taught by an adjunct faculty.

In light of the data limitations, we note that students enrolled in either online graphics courses had similar or better course success rates than the face-to-face graphics courses. The two online circuits courses have the lowest course success rates of all courses with alternative delivery methods presented (67% and 63% success rate), and had success rates considerably lower than the traditional face-to-face courses (82% and 96%). The materials course taught with the flipped classroom method also had slightly lower course success rates than the materials course taught with traditional method (75% and 79% course success rates vs. an average of 83%).

In terms of persistence, data were available only for graphics courses. Overall, persistence rate to enrollment in the next term was slightly lower for students enrolled in the online graphics course (71%) when compared to the persistence rate for students enrolled in face-to-face graphics course (73%).

Table 1. A summary of course retention and success of engineering courses piloted and offered between fall 2015 and fall 2016.

Course and Term	Outcomes	Type of Course	
Graphics		Online Course	Traditional Face to Face
Fall 2015	Enrollment	12	19
	Course retention	9 (75%)	11 (58%)
	Course success	9 (75%)	10 (53%)
	Term-to-term persistence	8 (67%)	12 (63%)
Fall 2016	Enrollment	12	18
	Course retention	11 (92%)	18 (100%)
	Course success	11 (92%)	18 (100%)
	Term-to-term persistence	9 (75%)	15 (79%)
Circuits		Online Course	Traditional Face to Face
Spring 2015	Enrollment	9	11
	Course retention	8 (89%)	9 (82%)
	Course success	6 (67%)	9 (82%)
Spring 2016	Enrollment	8	25
	Course retention	8 (100%)	25 (100%)
	Course success	5 (63%)	24 (96%)
Materials		Flipped Course	Traditional Face to Face (average of spring 2011 to spring 2014)
Spring 2015	Enrollment	16	8 students per term
	Course retention	13 (81%)	--
	Course success	12 (75%)	83%
Fall 2015	Enrollment	19	--
	Course retention	16 (84%)	--
	Course success	15 (79%)	--

5. CALSTEP's impact on transfer

It is too early to assess the overall impact that CALSTEP has had on transfer, although survey findings indicate that a growing number of students have been able to transfer sooner and/or bolster their transfer applications as a result of CALSTEP's expansion of course offerings.

In terms of increasing access to critically needed transfer courses, the most important CALSTEP offering may be Materials. This is a course many colleges don't offer because they lack the necessary facilities. One approach, tested by CALSTEP (see above) is for colleges without lab facilities to collaborate with other colleges that are able to host one or more lab sessions. As an example of how this can work, MPC's Materials course last year delivered a hands-on lab experience with a day-long site visit to Canada's facilities. The cost for this field trip and lab experience was just under $1,000. If colleges without the ability to offer the lab experience could be paired with nearby facilities that would open their doors, more students could complete these courses.

While the information is anecdotal and the sample size is small, the MPC instructor was told by three students in the Materials course that the lab course may have helped them obtain acceptance to Cal Poly's Engineering Program – one of the most desirable transfer programs in the state. Additional information was gathered from students in surveys conducted at COM where students enrolled in the Emporium courses were asked what impact the availability of the Emporium courses had on their transfer plans. In COM's MATLAB, 4 of 11 respondents indicated that without the class their transfer application would have lacked a course that could influence their ability to get accepted into their top transfer institutions; 4 would have had to travel to another community college to take the course during the semester; and 2 respondents noted their transfer would have been delayed. In Circuits, three of four respondents said that had the course not been offered their transfer would have been delayed and/or they would have had to apply missing a course that could influence their ability to get accepted into their top transfer institution. One respondent said he would have had to travel to another campus had Circuits not been offered. In COM's Materials, five of six respondents would have had to apply for transfer without having completed a course that could have influenced the strength of their application to transfer institutions and one student would have had to travel to take the course elsewhere.

6. Conclusion: What major lessons have been learned thus far?

CALSTEP has already improved opportunities for students in the CALSTEP colleges and in a growing number of colleges using CALSTEP curriculum and other resources (a) to access courses that hitherto were not offered or not offered frequently and (b) to participate in courses that use alternative instructional techniques and approaches. The CALSTEP instructional team continues to collaborate among themselves and with others to identify new technology and instructional approaches that expand and enhance learning opportunities for students.

Many lessons have been learned already, and the instructional team's commitment to continued improvement, including use of student input to guide course design and delivery, has resulted in the development of both knowledge and products that thus far have been disseminated through the CALSTEP website and at conferences such as SETI and the ELC.

Interest in using CALSTEP resources is already pronounced among a core group of instructors from other colleges around the state. Indeed, at both the 2016 and 2017 SETI sessions, a majority of participants expressed strong interest in joining a community of learners whose members include not just CALSTEP instructors but more than twenty additional faculty members who share an interest in testing and improving new technologies and alternative instructional approaches.

During the coming year, CALSTEP will seek to build on this momentum so that the CALSTEP curriculum and resources can become available to more students and faculty from around the state, including more remote colleges. This involves working with other groups and institutions, including the California Online Education Initiative to increase students' awareness of the fact that engineering courses and labs they need for transfer, but that are not offered locally, may be found online. Of particular importance is to reach students at colleges that do not have an engineering department (approximately 40 of California's 113 community colleges). In addition, CALSTEP is hoping to be see more colleges using the CALSTEP curriculum and resources to expand and enhance their own offerings, including through the addition of online options.

There is little doubt that there is strong interest in continuing the process of technology adaptation and integration and in expanding and developing the CALSTEP learning community. The challenge is that so many community colleges have engineering departments with only one full-time faculty who teaches numerous courses – leaving little time for community building and participation in professional development opportunities like SETI.

During the coming year, CALSTEP will offer a three-day SETI and the CALSTEP team will take additional steps to grow and strengthen the SETI community. The team will also seek to engage additional faculty members through the Engineering Liaison Council and through promotion of the CALSTEP website.

At the end of the grant period, recently extended to 2018, the goal is to have in place an expanded core group of faculty members from around the state that use and serve as local advocates for CALSTEP curriculum and resources. Within this kind of a framework, the CALSTEP team members believe the most effective way to continue to disseminate and grow CALSTEP's resources would be to have the CALSTEP colleges serve as hubs for one online subject area each. For example, MPC would serve as the hub for Circuits; COM for Materials; Canada for Engineering Graphics; and Skyline for Introduction to Engineering. The remaining subjects of Statics and MATLAB would also be centered in one of the four CALSTEP colleges.