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The Development of a Context-based Summer Research Program for Community College Faculty in Science and Engineering

Ms. Lea K. Marlor, University of California, Berkeley

Lea Marlor is the Associate Director of Education for the Center for Energy Efficient Electronics Science, a NSF-funded Science and Technology Center at the University of California, Berkeley. She manages undergraduate research programs to recruit and retain underrepresented students in science and engineering and also outreach to pre-college students to introduce them to science and engineering career opportunities. Ms. Marlor joined University of California, Berkeley in 2013. She has a B.S. in Materials Engineering from Rensselaer Polytechnic Institute.

Dr. Catherine T. Amelink, Virginia Tech

Dr. Amelink is Director of Graduate Programs and Assessment in the College of Engineering, Virginia Tech. She is also an affiliate faculty member in the Departments of Engineering Education and Educational Leadership and Policy Studies at Virginia Tech.

Abstract

Students enrolling in community colleges (CC) more typically come from non-traditional and underserved populations than students enrolled in four-year schools. Given current shifts in population trends, a greater emphasis has been placed on recruiting such non-traditional students in order to keep on pace with workforce demands for STEM students. Within the CC systems, reaching these students with engaging and inspiring educational modules is essential for getting more students involved in and interested in majoring in STEM-related fields. As such, the University of California, Berkeley has created a context-based research experience program for CC faculty to come to campus and conduct nine weeks of research while simultaneously attending workshops and seminars focused on curriculum development. The overall goals of this program are to train the faculty in what context-based curriculum entails, give them resources to change parts of their courses to be more hands-on, and provide them with real life examples of research that can be incorporated into their teaching. The research areas of this program are focused on alternative energy, cyber security, wearable medical devices, green and sustainable manufacturing, and nanotechnology. These areas were chosen because of their focus on real life problems that can be easily relatable for the students. This paper describes how this program was developed, as well as the comprehensive evaluation methods used to determine the effectiveness of the program as a professional development opportunity. Preliminary results from post-survey responses are also discussed with outcomes on improvements for future programs.

Introduction

Community colleges provide an opportunity to address STEM workforce needs. Therefore, it is important to consider the professional development of community college faculty. Faculty in community colleges need to have training and preparation that allows them to provide engaging and content-relevant curriculum to their students.[1] Context-based learning approaches have been identified as one type of pedagogical approach that can encourage student persistence to degree and facilitate student learning.[1]

Research shows that community college faculty need exposure to this teaching method as well as to other pedagogical approaches that encourage hands-on experiences for students.[2] Access to professional development opportunities that expose faculty to these methods is needed so that community college students receive an education that prepares them for career entry as well as for future degree opportunities if they transfer to four-year degree programs.[1]

Program Overview

In 2014, the University of California, Berkeley (UCB) received a 3-year grant to host 10 community college faculty members in research labs focusing on alternative energy, cyber security, wearable medical devices, green and sustainable manufacturing, and nanotechnology. Although these projects were mainly engineering based, CC faculty from all STEM disciplines were eligible to apply and attend this experience, so as to have a broader impact on the STEM community as a whole. Additionally, students majoring in engineering at a CC take most of their general requirements in STEM while enrolled at these schools before transferring to a four-year school to complete their more advanced technical requirements. Therefore, it's important to be

reaching out to all STEM faculty at CCs in order to have an impact on student interest in engineering.

The overall goal for UCB's Research Experiences for Teachers (RET) program is to improve the education offered within the CC system of California by developing the CC faculty professionally in order to give them the opportunity to create and enhance course curricula. Previous research has shown that course-work at the introductory level has led to high-performing students leaving STEM fields. Evidence shows that by improving teaching methods, students will be more likely to persist and succeed in obtaining an engineering degree.[1] Students who attend CC are typically more underrepresented in STEM disciplines.[3,4] Given the population trends of the United States, it's imperative to attract and retain students from more diverse backgrounds into STEM.[5]

Using research projects as a base, the community college faculty also attended workshops and seminars throughout the 9-week program that focused on context-based teaching. Additionally, faculty were given access to leading-edge research seminars and talks from UCB faculty about their current research and motivations for their projects as a whole for each topic (alternative energy, cyber security, wearable medical devices, green and sustainable manufacturing, and nanotechnology).

Each year since 2014, the RET program at UCB hosted CC faculty members for a paid 9-week summer professional development program. A CC faculty member is paid $9,100 stipend in 3 installments throughout the summer. Additionally, at the end of the internship, the CC faculty members have the option to receive an additional $1,000 implementation stipend. This additional stipend is received by the participants if they incorporate a portion of their research into a lesson plan, syllabus, or other course material.

Recruitment and Selection

Deans and chairs of science, math, and engineering departments were contacted in order to advertise this program. The funding did not provide for housing, so the selection was limited to those community colleges that were close to UCB. Given the size of the state of California's community college system, approximately 30 schools were within a commutable distance of Berkeley.

The RET program has a website (https://e3s-center.berkeley.edu/education-diversity/education/retsite/), and flyers and information were sent out prior to the application deadline. CC faculty were selected based on their own research interests, and the research projects available with the faculty from UCB. The application consisted of 2 sections. The first section included essays that focused on the CC faculty's research interests and interest in context-based teaching. Additionally, they were asked why specifically they wanted to work within the program. The second portion of the application consisted of information about what courses they teach, and approximately how many students they taught. Finally, the application also called for 2 letters of recommendation, with one coming from the chair of their department. Research interests were the main deciding factor on who was placed in labs, as the RET program wanted to ensure that the CC faculty enjoyed their research and found the program rewarding.

UCB faculty selected RET program participants and placed them in their labs with either a graduate student or postdoc mentor who would oversee their day to day activities. After selection, all graduate student and postdoc mentors were trained on project management, diversity, mentoring, and how to create a research project in order to ensure that mentors were prepared and capable of hosting the CC faculty.

Program Schedule

The program began the first week with an orientation that discussed the program elements and what was expected throughout the summer. Access was given to the labs and to the facilities during the orientation as well. CC faculty were then left with their mentors to work throughout the summer, advised mainly by their mentors. Four workshops were hosted throughout the summer, focusing on four distinct areas of interest: 1) Intro to context-based learning; 2) Strategies for developing context-based courses; 3) Online courses; 4) and Evaluation. These workshops were developed in conjunction with UCB's Center for Teaching and Learning, to ensure that the most up to date and best knowledge was being conveyed to the participants.

Additionally, the CC faculty attended 4 research seminars throughout the summer that focused on the research being conducted by faculty on UCB campus in various areas. The CC faculty also attended sessions by the leaders of the research topics (alternative energy, cyber security, wearable medical devices, green and sustainable manufacturing, and nanotechnology) that gave them an overall view of current research goals and progress. The goal of hosting these seminars is to describe real world problems being worked on, as well as providing access to leading-edge research outside of their own primary laboratory.

Beyond these seminars and workshops, CC faculty were asked to complete weekly homework assignments that asked them to reflect on their research progress and information they received throughout the summer. These homework assignments were designed to help the faculty review and learn more deeply about the information they had been provided in the weekly activities. The overall goal of these assignments was to challenge the CC faculty so that they can better update their curriculum.

At the end of the 9-weeks, CC faculty had the opportunity to give a "pilot course" to community college students who were on the UCB campus for the summer. These students were instructed to give feedback to the faculty on what they liked about the new course material and what they believed could be improved. This gave the faculty the chance to try out new course materials before actually presenting this material to their students within their CCs and also gave them the ability to hear from students about what worked and what needed improvement.

Evaluation and Assessment

This program was evaluated using both quantitative and qualitative measurements. Prior to their arrival, participants were given a pre-knowledge survey, and they were again surveyed at the completion of the program. The RET program employed an external evaluator for administering these surveys, to ensure anonymity. Additionally, at the completion of the program, participants were given the opportunity to offer candid feedback in a group session.

There are three complete and consistent years of data collected from the RET participants including the summer of 2015, 2016, and 2017. Across the three cohort years there were 13 participants that responded to the post-survey. All of the participants received a similar set of survey questions at the end of the experience. In addition, all of the participants received a longitudinal follow-up survey annually to track how they have applied what they learned during their RET experience.

Results

The following results report the mean responses to the post survey across all three cohort years. At the end of the experience faculty reported their experience with learning outcomes, research experiences, and overall professional development outcomes.

Learning Gains

The community college faculty participants developed confidence and knowledge with regard to context-based learning (CBL) approaches during the course of the RET program. Participants noted that they felt that they could apply the CBL practices to their classroom and knew about best practices about the use and application of CBL. The survey was administered during the last week of the experience when the participants had completed all of the summer workshops but had not yet implemented CBL in their teaching. However, at the end of the experience all of the participants strongly agreed that they were confident that they could try new approaches to teaching and learning in their classroom that focus on CBL.

The summer experience also addressed how faculty might be able to use CBL approaches that had a technology-based application and how to craft online modules or courses online. At the end of the summer experience, participants agreed that they felt somewhat confident they could convert traditional courses to online courses and effectively teach online. (See Table 1)

Table 1. Community College Faculty Learning Outcomes

(Scale: 1=Strongly Disagree, 5=Strongly Agree)	Mean (n=13)
I am knowledgeable about the term context-based learning	4.76
I understand how to apply context-based learning practices in the classroom	4.76
I am knowledgeable about the best practices surrounding the use and application of context-based learning in the classroom	4.49
I am knowledgeable about how to evaluate and assess context-based approaches to course/content delivery	4.44
I am confident in my ability to employ context-based learning practices in my courses	4.62
I am knowledgeable about how to convert traditional courses into online courses	3.96

I am knowledgeable about how to facilitate an online course	3.82
I am confident in my ability to design and teach an effective online course	3.82
I am familiar with context-based approaches to teaching that utilize technology based applications that emphasize societal benefits.	4.33
I currently use context-based approaches in my teaching that utilize technology based applications that emphasize societal benefits.	3.80
I think using context-based approaches in my teaching that utilize technology based applications that emphasize societal benefits will help my students learn content covered in my course(s).	4.56
I am currently engaged in research on current engineering topics.	3.62
I am aware of how to apply my research topics/projects to teaching that I am doing.	4.38
I connect the lessons and content that I teach to STEM careers.	4.71
I am currently connected to a network of other professionals at the community college and four-year university level (e.g., faculty, graduate students, post-docs).	3.89
I have access to online modules that are designed to contribute to scientific and engineering literacy.	3.70
I am currently engaged in the design and/or delivery of online curricular offerings that focus on context-based approaches.	3.42
I am currently engaged in the design and/or delivery of engineering design courses.	3.36
I am confident in trying new approaches to teaching and learning in my classroom that focus on context-based learning.	5.00
I often work as a team to design curricular modules for students.	3.62

Research Experiences

Post-survey data also provided insights to the research experiences that the community college developed over the course of the summer. Faculty noted they had an opportunity to observe research activities that others were doing, attend technical lectures, and collaborate with other researchers. While direct participation in the research was lower due to the knowledge gap that some faculty had in the technical areas associated with research projects, they did get hands on experience assisting in the development or modification of STEM research (See Table 2).

Table 2. Community College Faculty Perceptions of Their Research Experience

(1=Not at All, 4=Great Extent)	Mean (n=13)
I observed research activities that others were doing	3.46
I attended lectures that presented information about current work in science, mathematics, or technology	3.80
I collaborated in ongoing research with regular staff from the organization	3.66
I designed and implemented my own research or investigation under supervision from a mentor	3.40

I assisted in the process of developing, modifying, or documenting application of science, mathematics, or technology for my mentor/sponsor	3.44
I operated instruments, equipment, and other technologies	3.31
I participated in conducting research or collecting data out in the field	3.24
I read academic literature or journal articles	3.57

Additional Skills and Insights

The summer program was also designed to expose community college faculty to broader challenges in teaching and doing research in STEM areas. The faculty noted that they gained an understanding of how to apply STEM to their everyday life and increased their knowledge of current issues in STEM research. Faculty also noted that they increased their knowledge about challenges students encounter in studying STEM fields. Community college faculty did not indicate that they became more proficient at using the Internet as a form of communication with colleagues over the course of the summer and this may be due to the fact many of them were already well-versed in how to use the Internet for communication and accessing information to help with their teaching (See Table 3).

Table 3. Community College Faculty Reponses to General Questions

(1=Not at All, 4=Great Extent)	Mean (n=13)
I gained greater understanding of the applications of science, mathematics, or technology in everyday life	3.80
I learned about innovative ways to use standard materials and equipment in my field	2.95
I increased my knowledge of current issues in scientific or mathematical research	3.89
I gained a greater appreciation of the difficulties some student encounter when learning science or mathematics	3.37
I better understand how collaborative inquiry can be done successfully	3.49
I became more proficient at using the Internet for communicating with colleagues and accessing information that will be helpful in my teaching	2.95
I learned about magazines and professional journals that will be relevant to me as a teacher	3.03
I increased my knowledge of careers that utilize science, mathematics, or technology	3.26

Open-Ended Responses

The post survey included open ended questions that asked the community college faculty to reflect on the impact of the summer program as it related to their teaching and professional development. Faculty noted gains that would impact their teaching in a number of ways.

Faculty noted that they increased their understanding of and how to apply CBL to their classrooms, which would improve their overall teaching.

> *By participating in RET activities I gained greater understanding of context-based learning and sustainable manufacturing. My RET experience makes me think about ways I can improve my teaching.*
>
> *The assessment strategies that I learnt about during my RET program will help me create assessments that will encourage my students to take ownership of their learning and be motivated to gain mastery of the subject matter.*
>
> *Re-writing my Course Description in my Syllabus to reflect context based learning will enable my students develop critical thinking skills as they explore the key thought provoking questions about the subject matter of the course. A context based course description engages students from day one and actively creates a student-centered learning environment where the "instructor" becomes a guide/mentor/coach and not an "instructor". This helps students become life-long learners and increase student achievement*

Participants explained that exposure to cutting edge research had a positive impact as well:

> *Research cutting edge topics and bring back the knowledge to home institution.*
>
> *I learned so many useful strategies for teaching! I had a huge gain in understanding of semiconductor/electronics field. I enjoyed this experience tremendously. It was fun and stimulating to interact with researchers with a high level of thinking and reasoning, at the cutting edge of the field. It was also fun and stimulating to be around other community college teachers and educators who were extremely invested in teaching itself.*

Faculty also described how the experience would have a direct positive impact on their students.

> *Engaging in engineering research that has societal benefits that I can contextualize for my class room. This I believe will get my students (especially female and ethnic minority students) more engaged in the engineering profession.*
>
> *I strongly believe that my RET experience will have a strong impact on student achievement for the following reasons; During the RET program I gained a deeper understanding of how to create mental models through context based learning strategies. The use of context-based teaching/ learning strategies in my classroom will enable my students develop accurate/efficient mental models. With these mental models, students gain mastery of the subject matter quicker and retain the knowledge in their long-term*

memory thus having high achievements not only while in college, but also through out their engineering career. Context based learning strategies provide students with real life scenarios that enable students to apply knowledge of the subject matter in solving real life problems.

I'm generally more inspired and enthusiastic about teaching after this experience, so I'm sure my enthusiasm will transfer onto the students. I'm also planning to try out many of the new teaching strategies I learned to teach and assess better. I have developed a module on semiconductors, LEDs, and solar cells, so this technical knowledge I gained will be transferred to the students.

Exposure to university resources helps present materials at community college relative to what students should expect.

Faculty also described how the research experience positively impacted their professional development. One faculty member explained how they planned to apply what they learned to course development:

My RET experience gave me the opportunity to research into relevant issues in Green and Sustainable Manufacturing for Developing Economies. I plan to create team based engineering design mini-projects for my students from my research findings. These real life mini-projects will help my students develop a deeper understanding of sustainable engineering design.

I believe that using context-based approaches in my teaching will help my students learn content covered in my courses. By using context-based approaches, students acquire knowledge through collaborative inquiry which will benefit them in future learning.

Absolutely yes, I have learned new technology as well as new teaching techniques.

Yes, specifically from the curriculum workshops. I will definitely incorporate a lot of the active learning and assessment techniques that were presented.

Longitudinal Follow-Up

One year after their experience a follow-up survey was sent to all of the participants. Community college faculty were asked to report ways in which they used what they learned in the summer experience to modify curriculum. Faculty noted several ways they have used the skills and knowledge gained during the RET and the impact that they perceived from those applications. Several faculty noted an increased use of group projects and hands-on learning activities. Some examples from faculty include:

Definitely! I have already started embedding some of the research from my RET experience in my classrooms. My students are more engaged in my electric circuits class.

In our physiology class, we now do a 3 day workshop on computational programming and data analysis skills which I used and developed during the summer. This workshop

is a hands on experience for students, giving them practice actually using coding/programming techniques.

I have used the unit that I created for the summer program in my classes instead of standard lecture in order to cover marine conservation topics. I have also used different strategies to organize my lectures

Teaching the Metric system in the context of nanotechnology. The students learned and were successful in quantitative units conversion problems.

I have increased discussion of energy efficient electronics science in my Materials Science course. This reaches 30 students per year. Students seem to appreciate the material.

I have introduced new material on electricity grid fundamentals/challenges/opportunities, etc related to renewable energy. We use the electricity grid simulator from my RET project. Students love visualizing and interacting with the grid in a more tangible manner. The feedback is very positive, and students are able to make the connections between concepts and practical challenges.

Discussion

Results indicate that CC faculty experienced multiple positive gains during the RET experience. Workshops and seminars gave faculty strategies on how to implement their work into course content. Faculty were able to garner an understanding of CBL and how to apply it in course development. While another goal of the program was to encourage faculty to put courses or modules online, CC faculty did not express seeing as much relevance in doing this. This may be due to the nature of the way courses are taught at their particular CC and not having the incentive or resources to put courses online easily. The CC faculty stated that the opportunity to do research greatly enhanced their understanding of current technologies, and offered them ideas on how to improve their curriculum. Having exposure to the resources, cutting edge technology and opportunity to participate in some aspects of the ongoing research allowed faculty to consider new and exciting course content for students. The research engagement also challenged them in new ways as they learned new content and helped them to learn new skills. Faculty noted that the experience led them to consider larger issues in STEM such as student learning challenges and how to encourage students to pursue long term career opportunities in STEM fields.

In terms of actually going through and implementing the coursework, approximately 80% of the faculty opted to do so within the first two semesters after leaving the UCB campus. Faculty provided feedback with regard to the positive impact that using CBL approaches were having as they incorporated them into their classrooms.

Challenges Encountered

The original grant for this program funded 10 CC faculty for 3 years. However, despite great effort in recruiting, each year has seen a maximum of 5 faculty selected and placed into labs. Given the location of the program, there is quite a bit of competition for other internships from

industry that the faculty can take part in. Additionally, because there is no housing attached to the grant, we have been unable to recruit more broadly for this program in order to fill the gaps. Finally, many CC faculty have decided to work within the CC system because they no longer wanted to participate in research after earning their Ph.D.'s, and instead want to focus on teaching. These are all possible reasons for the understanding why there has been limited excitement amongst faculty members to join the RET program.

Limitations

While not the scope of this study, future studies could look at the impact of this training program on student development. Additional follow up with the students could determine if the implemented coursework was increasing, decreasing, or having no effect on their interests in pursuing a degree in engineering.

Conclusion

The faculty that took part in this program witnessed considerable growth throughout the summer with access to teaching workshops and seminars. They learned new ways in which they could present STEM disciplines to their students, and have given positive feedback on how it has impacted their teaching strategies. While faculty stressed the importance of being able to do research during the summer, they also underlined the importance of being able to attend workshops that allowed them to learn the best and most current ways of teaching science. They emphasized that this was not a resource that they had at their CCs, and stated that this was extremely important in how they were working to update their course content. Additionally, the faculty stated that learning what current research is focusing on helped them to create real-world examples to give to their students. With more real-world problems being focused on in the classroom, they hoped that they would be able to reach more students with the importance of continuing on in STEM degrees.

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