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Creating Collaborative Spaces for Community College Faculty and Staff to Discuss Pedagogy

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ABSTRACT

Research from undergraduate and K-12 environments suggests that providing meaningful support for Community College students requires faculty and staff to engage in ongoing self-reflection, peer support, and a commitment to research-based pedagogical shifts. Currently, California Community College (CCC) faculty and staff get very few of these opportunities. This study aims to address this issue through an intervention designed to provide opportunities for CCC faculty and staff to be part of a flexible, coherent professional learning community. The intervention is part of an NSF-funded research and development project at a community college in central California designated as a Hispanic Serving Institution (HSI), with the goal of providing faculty and staff with tools and processes to support students toward higher retention and success in STEM by facilitating "micro-internships." Micro-internships are designed to reduce inequalities inherent in the traditional internship paradigm by providing access to professional and research skills for students who do not have the opportunities and/or confidence to participate in a more traditional full-length internship. Conversations with participants showed how they embraced the design principles that were negotiated as a project team, and how one or more of the study interventions had played a powerful role in supporting their learning and development toward certain pedagogical shifts. Our results highlight the power of providing spaces such as summer workshops and ongoing "community of practice" meetings for collaboration, professional learning, and peer-to-peer mentorship.

PLAIN LANGUAGE SUMMARY

We worked with faculty and staff at a community college in California, offering a weeklong summer workshop and monthly check-in meetings. The focus of this work was designing and running workshops with students that we call "micro-internships." In collaboration with faculty and staff, we developed a set of design principles to support instruction that is authentic, meaningful, and useful for students at this Hispanic Serving Institution (HSI). Data taken from faculty and staff over the course of the project suggest that the time they have spent together co-designing and discussing their teaching practice has been very valuable. These results suggest that we should be creating more spaces for community college instructors to have facilitated conversations about what works with their students.

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Introduction

Problem

Decades into the effort to diversify STEM, there is still much work to be done at undergraduate institutions (Barber et al., 2020; Lerback et al., 2022; Mourad & Middendorf, 2022). Even as the share of science and engineering bachelor's and doctoral degrees awarded to Latine, Black, and American Indian or Alaska Native graduates has increased over the past two decades, these groups are still underrepresented in STEM relative to their representation in the overall population. In 2021, Latine, Black, and American Indian or Alaska Native persons collectively accounted for 37% of the U.S. adult population under 34 years of age, but only 26% of STEM bachelor's, 24% of STEM master's, and 16% of STEM doctoral degrees earned by U.S. citizens and permanent residents in 2020 (NCSES, 2023).

California Community Colleges (CCCs) represent a key leverage point for recruiting and retaining a more diverse STEM workforce. According to the Association of American Community Colleges, more than half of community college students identified as not white in 2020 data. This puts CCC STEM faculty and staff in a unique position to support the diverse student body attending CCCs.

Research from undergraduate and K-12 environments suggests that providing significant support for students requires faculty and staff to engage in ongoing self-reflection, peer support, and a commitment to research-based pedagogical shifts (Loucks-Horsely et al., 2009; Roth et al., 2019). Currently, CCC faculty and staff get very few of these opportunities. This is in large part due to structural constraints on their time, including service obligations in the face of fewer institutional resources, and heavy teaching workloads. In addition, because of a growing overreliance on adjunct positions at CCCs, faculty are often moving from school to school to ensure a full workload (Peele, 2022; Rhoades et al., 2024). Thus, even though CCC faculty and staff tend to have fewer obligations to research and grant applications than their equivalents at four-year institutions, it is still very difficult for CCC faculty to participate in coherent professional learning and peer networks that support self-reflection and real pedagogical shifts.

This study aims to address this issue through an intervention designed to provide opportunities for CCC faculty and staff to be part of a flexible, coherent professional learning community. The intervention is part of an NSF-funded research and development project at a community college in central California designated as a Hispanic Serving Institution (HSI). This project aims to build on the strengths of institutions like this one, which are quite literally built to serve their communities, to give faculty and staff the opportunity to engage in conversations with their peers to support meaningful interactions with students that research suggests could increase retention and success in STEM.

Micro-internships

The goal of the project described in this paper is to intervene with CCC faculty and staff to provide them with tools and processes to support students (Latine[1] students and non-males[2] specifically) toward higher retention and success in STEM. The learning experience that serves as a "sandbox" for faculty and staff to try out new pedagogies in this context is called a "micro-internship," or MI. Students without connections in industry or academia, reliable transportation, childcare, or the flexibility to take on part-time, low-paid (or unpaid) work face significant barriers to finding, securing, and completing a traditional internship (Blumenstyk, 2019a, 2019b). Micro-internships are designed to reduce inequalities inherent in the traditional internship paradigm by providing access to professional and research skills for students who have not had the opportunities to participate in a more traditional full-length internship, or who have been stripped of the confidence to participate in an internship because of racism, classism, sexism, or all three. Each micro-internship is approximately 25 contact hours, scheduled to make attendance easy while attending school full time, and takes place virtually, on campus, or at an easily accessible location in the region.

Culturally responsive pedagogy in the HSI context

Community colleges, and Hispanic Serving Community Colleges in particular, represent a key leverage point for nurturing the brilliance and potential of their diverse student populations (Andrade & Lundberg, 2018; Espinosa et al., 2019; Núñez et al., 2015). HSIs support academic and nonacademic outcomes (e.g., Arana et al., 2016; Flores & Park, 2015; Garcia, 2013) and have been described as "engines of social mobility" for Latine students (Rodríguez & Calderón Galdeano, 2015). HSIs can even be spaces of liberation and justice when instruction centers Latine cultural practices (Cuellar et al., 2017; Garcia et al., 2019).

The HSI designation is intended to support schools toward meeting the unique needs of Hispanic and/or Latine students. The framework for operationalizing this is called *servingness* (Garcia, 2020; Garcia et al., 2019). The growing literature based on servingness at HSIs showcases the diversity of this category of institutions. Just because an institution has been given the designation of HSI does not mean that it is serving its student population or even meeting the basic needs of that population. According to Garcia (2017), an HSI might be Latine enrolling (many students who identify as Hispanic enroll) and even Latine producing (many students who identify as Hispanic graduate), but that does not mean that the institution maintains a culture that serves Latine students by enhancing their educational and racial/ethnic experience (Garcia, 2017). Student instructional experiences need to incorporate culturally relevant practices that treat students' community cultural wealth as a resource rather than as a barrier (Castro Samayoa et al., 2020; Garcia & Okhidoi, 2015; Garcia et al., 2020; Núñez et al., 2010). Toward this end, the faculty workshops and monthly meetings that followed included analysis of current programs through the lens of meaningful, collaborative STEM activity informed by Culturally Responsive Pedagogy (CRP), and newer formulations of the theory such as Culturally Sustaining Pedagogy (Paris, 2012). CRP recognizes the situated nature of knowledge and incorporates students' social and cultural references into all aspects of learning (Ladson-Billings, 1995). The workshops and monthly meetings supported the development of a common vision for micro-internships as (a) responsive to students and (b) aligned with repertoires of practice research has shown to be culturally aligned to local Latine communities. Research shows that Latine students' repertoires of practice tend to align well with learning environments where work is meaningful and authentic (Rogoff, 2014), where instruction emphasizes analogy to the real world, and where hybrid language use is encouraged (Buck Bracey, 2017; Rogoff et al., 2016). Latine students describe thriving in environments that provide opportunities for collaboration, draw on their diverse and rich cultural capital, and address issues that they see as meaningful for their families and communities (Contreras Aguirre et al., 2020; Rincón & Rodriguez, 2021). These principles served as the foundation of the design principles developed during the faculty workshops, described below.

Faculty intervention

CCC faculty and staff who led the micro-internships (who we will call MI leaders) participated in an annual 4-day summer workshop and ongoing monthly meetings throughout the year with the goal of co-constructing a shared vision for what micro-internships should look like, engaging in conversations about pedagogy and learning, and nurturing an ongoing community of practice that will sustain the micro-internship program going forward.

Faculty workshops were guided by a cognitive apprenticeship model of instruction (Lave & Wenger, 1991), in which learning is embedded in collaborative, productive activity. In the cognitive apprenticeship model, novices, upon learning new knowledge and skills, take on more central roles in the community while expert guidance fades (Brown et al., 1989; Lave, 1988). This model has been shown to lead to an increase in pedagogical content knowledge (PCK), which describes the knowledge that teachers need to teach a particular subject effectively (Wilson et al., 2018). It includes not just knowledge of the subject matter but knowledge of how to teach that subject in a way that is engaging and effective for students.

Faculty workshops relied on the SIMPL model of professional learning (Mumme & Seago, 2002; Lauffer, 2010) to build capacity at the CCC for leadership. An important element of this model is an experience as a student-learner, embedded in an experience as a teacher-learner, embedded in an experience as a leader-learner, as shown in Figure 1. The chronology of experiences in this model begins by engaging participants as leader-learners by presenting them with a problem of practice they may face as leaders and eliciting prior ideas and experiences as leaders working to address the problem of practice (in green). Participants are then invited to explore the problem of practice (or another related problem of practice) as it manifests in classrooms, taking on the perspective of a teacher-learner (in yellow). To explore the problem as teacher-learners, participants take on the perspective of student-learners in a STEM learning environment where the problem is relevant. The student-learner experience (in blue) engages learners' curiosities by presenting a phenomenon or design problem that is puzzling or needs to be solved. Learners are then given a chance to engage in authentic scientific practices to figure out ideas that could help them explain the phenomenon. They are then given a chance to explain the phenomenon or address the design problem as students. Next, they step back out into the teacher-learner experience, using the shared student-learner experience to explain and reflect on the teacher-leader focal problem of practice. Finally, participants step back out into the leader-learner experience, using the shared teacher-learner experience to reflect on the leader-learner problem of practice and develop strategies and solutions as leaders.

Table 1, below, shows the student-learner, teacher-learner, and leader-learner experience for each workshop over the course of the project. The workshops in Year 1 and Year 5 were held in-person, either on campus or at a venue nearby. Workshops in Years 2 and 3 were virtual due to the COVID-19 pandemic. Note that there was no leadership component in the first workshop, as everyone entered as first-time participants. There was also no summer workshop in Year 4 due to the constraints of the funding.

Co-development of design principles

Workshop facilitators introduced literature about CRT, described how people learn, and provided frameworks for supporting diverse epistemologies. Over the next year, participants worked together to refine a set of design principles based on this literature, as well as their own experiences in the CC context. The design principles are:

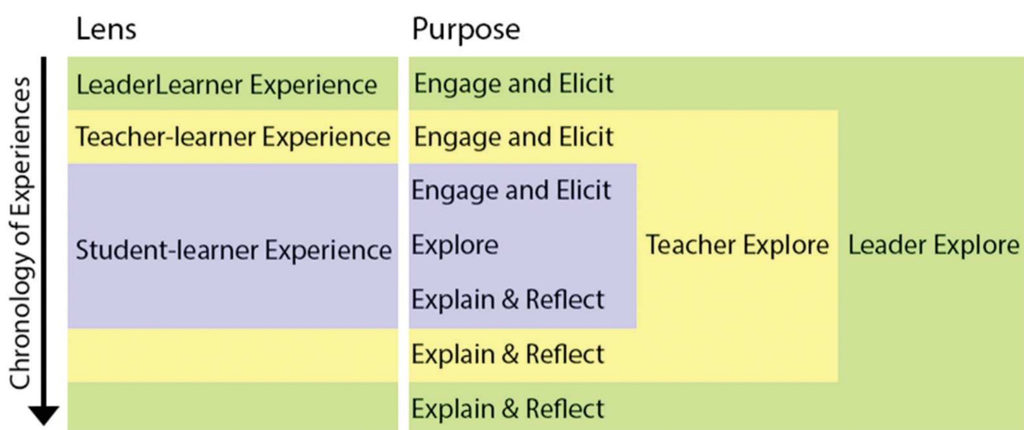

Figure 1. Faculty workshops relied on the science immersion model for professional learning (Mumme & Seago, 2002; Lauffer & Lauffer, 2009) to build capacity at the CCC for leadership. An important element of this model is an experience as a student-learner, embedded in an experience as a teacher-learner, embedded in an experience as a leader-learner.

Table 1. Focal topics and problems of practice guiding the embedded experiences for the four summer workshops, based on the model for professional learning in Table 1.

	Year 1	Year 2	Year 3	Year 5
Leader-learner focus	n/a	Designing professional learning experiences	Social justice in our design principles	Agency to take on leadership roles
Teacher-learner focus	Designing "authentic" STEM experiences for students	Putting our design principles into practice	Social justice in the design of learning experiences	Supporting student agency in and out of learning settings
Student-learner focus	Developing Arduino-driven solutions to determine when to irrigate plants.	Modeling COVID-19 spread to determine when to close schools.	Culturing bathroom bacteria to investigate various cleaning products' effectiveness.	Improving driving safety in our community based on fundamentals of physics.

(1) The MI begins with the introduction of **meaningful phenomena and problems that will engage learners and drive learning**. The phenomenon/problem should:
   (a) be clearly relevant to students' everyday lives, local ecosystem/community, and/or global interests.
   (b) reflect a diversity of experience and perspectives without essentializing students' social/cultural identities
   (c) be introduced with explicit space for students to share their experiences, interests, and ideas related to the phenomena/problems.
   (d) communicate consistent, high expectations for the kinds of issues students can contribute to meaningfully.
   (e) be complex enough that it will require at least 25 contact hours for students to solve/figure out/contribute to.

(2) The MI includes ample **opportunities for collaborative exploration** that:
   (a) allow learners to fulfill valuable but varied cognitive roles in the group (i.e., not time-keeper) at various levels of expertise.
   (b) require the use of specific relevant skills (such as coding, soldering, software, gathering references) at a level that is above what one student can already do alone, and that can be added to a resume.
   (c) are rooted in an inclusive culture established in the larger group that encourages the diverse contributions of every student as valuable.
   (d) provide space for learners to guide and be guided by their peers and the MI leader(s) in accomplishing tasks.
   (e) require authentic communication among learners that builds on shared reference (a shared experience, problem, task, goal).
   (f) are facilitated and scaffolded by the MI leader when appropriate.

(3) The MI concludes with a culminating product that gives students **an authentic chance to explain and reflect by**:
   (a) helping solve or explain the phenomenon or problem that is driving the learning.
   (b) requiring students to take initiative and engage in productive struggle.
   (c) demonstrating/explaining/reflecting on what they have learned.
   (d) requiring engagement in real STEM practices (such as solving design problems, designing and carrying out investigations, communicating scientific information, etc.) to complete.
   (e) communicating consistent, high expectations for the kinds of skills students can master.
   (f) allowing space for students to establish agency by including built-in flexible opportunities for students to "make it their own."
   (g) providing opportunities for formative assessment in the context of authentic work that they are already engaging in, with the purpose of supporting learners as they contribute to the shared endeavor.

Materials and methods

Data, participants, and context

The school at which the program was implemented is a CCC identified as an HSI enrolling over 17,000 students, with over 3,000 STEM majors. The college represents the only affordable post-secondary option in a rapidly growing agricultural region, with over 70% of students identifying with a racial or ethnic minority group. Sixty percent of students identify as Hispanic, and 56% report being in their families' first generation to attend college. This project was a collaboration between this CCC and a science education nonprofit. Approximately 15 faculty and staff from the CCC participated in this project (see Table 2). Several additional participants joined the group for conversations about pedagogy and design, but only ten faculty and two laboratory technicians actually held micro-internships over the course of the project. For the purposes of this study, we interviewed four faculty (who we will call Christopher, Jake, Rodney, and Patience), and two laboratory technicians (who we will call Samantha and Mateo).

We collected survey data from participating faculty/staff and students, conducted focus groups with faculty/staff, and interviewed selected faculty/staff. We also collected data from classroom observations during the micro-internships. Four interviewed participants (Christopher, Jake, Samantha, and Mateo) began as novices in the space, and grew in their expertise until they became MI leaders for new participants. Two interviewed participants (Rodney and Patience), both faculty, were still fairly new in the community of practice space. MI leaders are listed in Table 2, along with details about their role, their participation in the intervention, the number of MIs each led, and the data types available for each.

Faculty surveys

Faculty and staff who were leading micro-internships were sent a survey in the week prior to the start of the micro-internship. This survey asked them about how they planned to incorporate specific design principles into the micro-internship, with questions such as:

- What are the visible products that you expect from your students? For example, do students produce a paper, a presentation, enter a competition, design a solution, etc?
- What problem(s), question(s) or task(s) will drive the learning in your micro-internship? How is this meaningful for your students?
- How will the problem, question, or task reflect your students' experiences or interests?
- How will you structure your micro-internship to allow students the opportunity to work collaboratively and cooperatively?
- How will your micro-internship support students in increasing their confidence, interest, and persistence in STEM?

Faculty interviews and focus groups

Faculty and staff who were leading micro-internships were interviewed in two ways. Two years into the project and 4 years into the project, leaders participated in focus groups led by the project evaluator. The evaluator provided feedback to the research team, and with the permission of participants released responses to specific questions to the research team to analyze. The questions from the focus group that were provided to the research team were related to participation in a sustainable community of practice, and perceived student outcomes. These questions included:

- Do you feel like the workshop and community of practice made you feel like you are part of a community?
- How did participation in the workshop and communities of practice contribute to your sense of being part of a community? How could it have better supported community development?

Table 2. List of MI leaders who participated in the project (pseudonymized), their role at the CCC, a description of their participation in the intervention, the number of MIs each led, and the data types available for each.

Pseudonym	Role in Project	Participation in Intervention	# MIs	Data Sources
Samantha	Lab tech (biology) at another institution	Attended every summer workshop and consistently attended CoP meetings	4	Focus group Pre-MI surveys Interview
Mateo	Lab tech (physical science and engineering)	Attended every summer workshop and consistently attended CoP meetings	7	Focus group Pre-MI surveys Interview
Jake	Full-time faculty (biology)	Attended every summer workshop and consistently attended CoP meetings	8	Focus group Pre-MI surveys Interview
Rodney	Full-time faculty (biology)	Joined halfway, attended two summer workshops and consistently attended CoP meetings	2	Pre-MI surveys Interview
Patience	Adjunct faculty (biology)	Joined halfway, attended two summer workshops and consistently attended CoP meetings	3	Pre-MI surveys Interview
Christopher	Full-time faculty (chemistry)	Attended every summer workshop and consistently attended CoP meetings	1	Focus group Pre-MI surveys Interview
Ham	Full-time faculty (math)	Attended every summer workshop and consistently attended CoP meetings	2	Focus group Pre-MI surveys Interview
Abdul	Full-time faculty (math)	Attended every summer workshop and consistently attended CoP meetings	3	Focus group Interview
Cai	Adjunct physics faculty (physics)	Attended two summer workshops and consistently attended CoP meetings before leaving the program	3	Focus group Pre-MI surveys Interview
Andrew	Full-time faculty (math)	Attended part of every summer workshop and consistently attended CoP meetings	5	Focus group Pre-MI surveys Interview
Sally	Adjunct faculty (biology),	Joined halfway, attended one summer workshop and a few CoP meetings	1	Focus group Pre-MI surveys Interview
Briana	Adjunct faculty (biology),	Joined halfway, attended two summer workshops and consistently attended CoP meetings	2	Pre-MI surveys Interview
Nora	Independent,	Joined halfway, attended a few CoP meetings	1	Focus group Pre-MI surveys Interview
Andreas	Full-time math faculty	Attended every summer workshop and consistently attended CoP meetings	1	Pre-MI surveys Interview
Linda	Full-time faculty (engineering)	Did not participate in any aspects of the intervention	1	N/A

- Since the summer workshop, and not counting our official monthly meetings, have you had any additional conversations with faculty who attended the workshop about micro-internship design or applied learning theory?
- Since the summer workshop, have you had any additional conversations with faculty who did not attend the workshop about micro-internship design or applied learning theory?
- If you have already facilitated a micro-internship, what kind of student growth did you observe?
- What outcomes do you anticipate for students moving through the micro-internships. Why?

In addition, the research team reached out to individual participants in the last year of the project to conduct interviews about their overall experiences. These interview protocols were designed to ask about specific themes that were arising in the data, with protocols for how to follow up on leader responses. We asked about micro-internship structure, the impact of COVID-19, and specific challenges/affordances of participating in the project. An example of a question focused on participation in the project from this protocol is below:

- What were the impacts of interacting with your colleagues who were also planning or implementing MIs?
  - On your research?
  - On your teaching?
  - On collaborative opportunities with your colleagues?
  - Was this interaction primarily through the CoP meetings, the summer workshop, during meetings that you set up, or informally?

Micro-internship observations

We implemented an observation protocol in which a researcher observed the MI for an hour sometime within the first 8 h of the MI, again during the middle 8 h, and once more in the final 8 h. This allowed us to get a glimpse into the MI activities as they occurred and observe group structure, student activities, and MI leader actions. These observations were then combined for each MI to provide a percentage of time that each group structure, student activity, and MI leader action was implemented during observation.

The observations were made using a protocol adapted from the the Classroom Observation Protocol for Undergraduate STEM (COPUS) (Smith et al., 2013). The observer marked for each 5-min time interval during their observations: 1) the structure of the group, 2) what students were doing, and 3) what the leader was doing. The possibilities for each are listed below:

What is the structure of the group?

- Individual work
- Working in small groups
- Working in large groups
- Whole group (facilitated or un-facilitated)

What are students doing?

- Listening to the leader
- Engaged in discussion
- Skill Practice.
- Modeling/Designing in Context
- Investigation/Building/Coding in Context
- Preparing for a presentation.
- Presenting
- Assessment
- Waiting or socializing
- Other

What is the leader doing?

- Lecturing
- Engaged with one individual
- Engaged with a small group
- Not engaged with students
- Observing students
- Other

A detailed observational protocol manual co-developed by the project co-PI and two of the observers was used to ensure reliability across observers. To quantify inter-rater reliability we calculated Cohen's Kappa for each pairing of raters observing the same classroom for an hour, and averaged to get Light's Kappa. The value for the codes related to the group structure was $\kappa = .904$. For what the mentor was doing the value was $\kappa = .634$. For what the student was doing, the value was $\kappa = .818$. The average across these is .785. Generally, a kappa over .75 is considered excellent agreement.

Ethics approvals

The research described here involves human subjects. It received an exemption from the IRB at BSCS Science Learning in Colorado Springs, CO (#00006625). The IRB deemed the research (including each form of data collection described above) to be exempt based on the Exempt research 45 CFR § 690.104 category 2, research that only includes interactions involving educational tests, survey procedures, interview procedures, or observation of public behavior (i) and the information obtained is recorded by the investigator in such a manner that the identity of the human subjects

cannot readily be ascertained. Faculty and students were required to give informed consent for participation prior to every survey, which included a description of potential risks, benefits, and instructions on how to withdraw from the study at any time.

Analysis

Our initial coding of the surveys, focus groups, and interviews was based on the design principles co-created by the participants and project leads. Specifically, responses were coded into the three primary categories – meaningful phenomenon and problems, opportunities for collaborative exploration, and authentic project outcomes – and further coded into their subcategories. Table 3 illustrates the dimensions we coded for the design principles and example responses for each dimension. Note that classroom observations were simply counted and quantified as shown in Figure 2, they were not coded using the categories described here.

In addition to the categories that were derived from the design principles, three additional categories for coding participant responses emerged as we engaged in our analysis. The first additional category was MI leaders' goals for their students. The second additional category was

Table 3. Design principles, and the codes corresponding to the dimensions of that principle. Empty responses mean that there were no responses coded in that category. See "co-development of design principles" section for a full description of these categories.

Design principle	Dimension/Code
Meaningful phenomenon and problems	Relevance to students Diversity of experiences and perspectives Space to share experiences, interests, and ideas Expectation to make meaningful contributions Sufficient complexity for a 25±hour project
Opportunities for collaborative exploration	Meaningful cognitive roles Inclusive culture Opportunities for peer guidance Authentic communication Facilitation by MI leader
Authentic project outcomes	Solve or explain phenomenon or problem Student initiative Reflection on MI Engage in STEM practices Develop new technology skills Student agency/ownership Opportunities for formative assessment

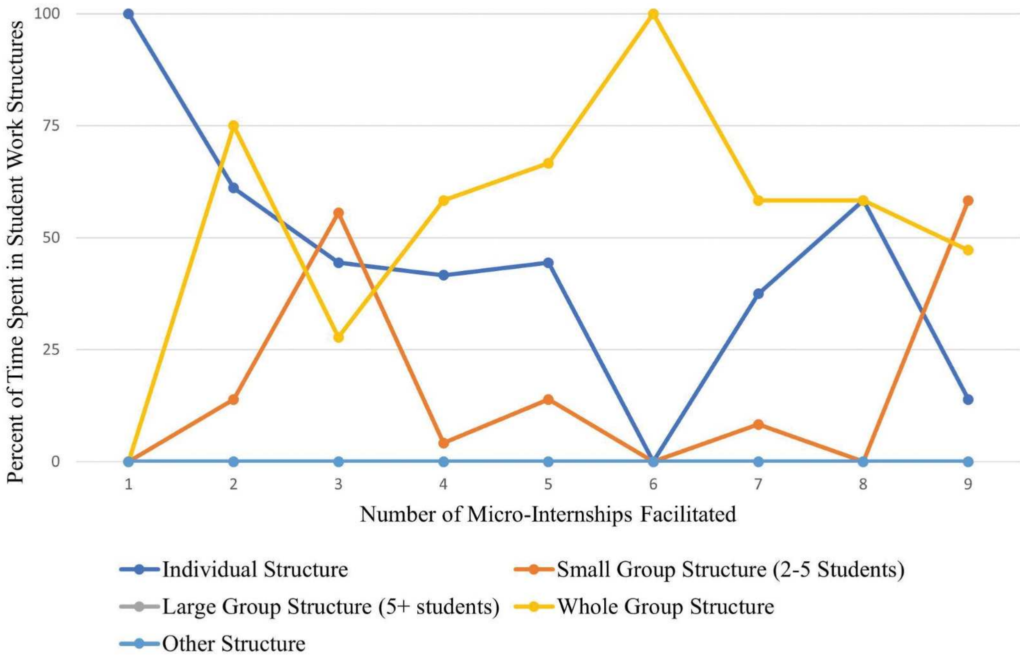

Figure 2. Mateo began with an MI that was entirely individual work. However, in this MI leader's next MI we saw an increase in whole group structure, a drop in individual structure, and the first implementation of small groups. Through Mateo's next seven MIs, a variety of group structures were implemented, and in his most recent MI, over 50% of the observed time was spent in small groups.

the impact of MI leaders' participation in the summer workshops and CoP sessions. A final additional category was the impact of the COVID-19 pandemic on scheduling and conducting MIs. The pandemic occurred mid-way through the project. Table 4 shows these additional categories and example responses for each.

Results

Results overview

Our initial coding of the surveys, focus groups, and interviews was based on the design principles co-created by the participants and project leads. In addition to the categories that were derived from the design principles, the three additional categories identified above for coding participant responses emerged as we engaged in our analysis.

Table 4. Additional coding categories and example responses.

Additional category	Example response
MI leaders' goals for students	*My hope is that the students will gain more interest in genomics as they progress through this two week Micro-Internship. If this project is a positive experience I believe students will want to seek out other MIs and/or summer internships at four-year institutions.*
Impact of workshops and CoP sessions	*I think just in general it was great to get ideas from these community of practice meetings. It was great to get ideas for the next semester with our monthly meetings. That collaboration, or interaction, led to quite a bit of good ideas and improvements on what I was trying to do.*
Impact of pandemic	*It felt isolated, obviously. It was I don't think as fruitful as it could have been, because they did not get that experience of sitting in a room together and hashing out what they were seeing, which would've been, I think, the most valuable portion of it, besides the theoretical aspect of is the data any good?*

Conversations with MI leaders showed how they embraced the design principles that were negotiated as a project team. Their comments represented all three categories – relevance and meaning, collaboration, and chances for students to explain and reflect. In addition, several MI leaders described changes in the way they teach their classes and the impact of COVID. All the MI leaders described how one or more of the study interventions (summer facilitated workshops, opportunity to engage in conversations with their peers as part of the ongoing community of practice) had played a powerful role in supporting their learning and development toward certain pedagogical shifts.

Design Principle 1: Meaningful phenomena and problems that will engage learners and drive learning

MI leaders addressed the first design principle by discussing how they designed their MIs to be relevant for their students, and how students might make meaningful contributions to the field. These two codes together accounted for nearly half of the MI leaders' comments related to the first design principle.

The ways in which MI leaders conceptualized and discussed relevance varied. From the beginning, many MI leaders conceptualized relevance in terms of what students needed to advance their own careers ($n = 6$). This remained important to MI leaders throughout. For example, "Mateo" commented:

> I found out that here in [nearby town] . . . there's a company that uses Arduinos for irrigation, their plant. So I want to do something that students can take and maybe they can get a job using this microprocessor.

Two other MI leaders spoke about helping students make connections to nearby tech companies in Silicon Valley to develop career skills that would make them attractive applicants in the future.

Other comments described how MI leaders' MIs were relevant to students' everyday living. For example, "Christopher" said:

> They are drinking water every day out of the tap, out of a bottle. I wanted them to say, "Oh, is this water good?" How does all of these things around, these environmental influences affect you?

A few MI leaders conceptualized relevance less in terms of the individual, and more in terms of value to the community. One MI leader, Samantha, an early-career biology lab technician, described this type of relevance in detail.

Fecal coliforms are kind of an important tool to look at because it can give you indicators of if the level is high, there could potentially be pathogens in the water, which are harmful for recreational use . . . sometimes kids go in the water . . . . Another group wanted to look at [a local] Lake, which we know is a huge dumping ground. [There are] lots of homeless encampments. We compared that to an area . . . where there were no homeless encampments. Then, we saw that there was a significant increase in contamination and fecal Coliforms in the area where there were homeless encampments. So that project was looking more at the impacts of if they're living there, are they going near the water? Is that safe for them? How does that also impact the community?

About a quarter of leaders' comments in interviews, focus groups, and surveys about Design Principle 1 were related to contributions that students' work in the MIs made to the field. For example, a mid-career biology faculty member, Jake, commented, "This will represent the first complete analysis of those two chromosomes for this red algal family, the Caulacanthaceae."

"Patience" also noted the importance of her students' healthcare findings from the results of their MI.

This is what we found in the study regarding that, how important the lifestyle changes to be able to control blood pressure, not just relying on taking the prescribed medication because this is not going to be enough.

Only five of the fifteen MI leaders' comments related to other aspects of Design Principle 1, including choosing an entry point that reflects a diversity of experience and perspectives without essentializing students' social/cultural identities, creating an explicit space for students to share their experiences, interests, and ideas related to the phenomena/problems, and choosing an issue that is complex enough that it will require at least 25 contact hours for students to solve/figure out/contribute to. A few MI leaders talked about intentional moves to help students see relevance and meaning by providing space for students to share experiences, interests, and ideas. For example, one leader said that they "had them think about where they may have seen something like this in the past" in order to surface student ideas and experiences. But in general, MI leaders were most focused on making the experience relevant for students and providing opportunities for students to make meaningful contributions to the field.

Design principle 2: Opportunities for collaborative exploration

Several MI leaders noted that they required students to work in groups or teams for the MI but they did not elaborate on strategies they used to support collaboration. For example, Jake explained that in his MI, "They are all assigned to groups with three teammates." In fact, several MI leaders' comments suggested a lack of intentional planning for facilitating student collaboration. Rodney said, "They worked in teams. I gave them the liberty of picking out their teams. Typically, it ended up being the members in the same table." Another MI leader, Cai, said, "I thought that they would learn something about working together as a team, mainly teamwork."

About 20% of MI leaders' comments coded for Design Principle 2 were related to the purpose of group work as allowing for mutual guidance. Mateo explained this, noting:

> I encourage them to ask questions between them . . . because I can find some students, they have some experience programming. There's other students, they never opened a programming software, so they're afraid, they're scared that they don't know how to do it. So [I put them] in pairs . . . I encouraged them to work together.

Jake gave a similar example.

I ask them to do this as well, and say that after you complete this step, then help the people around you work with each other. And they are pretty good at asking each other, "Hey, I don't know what's going on here." And they go around and help, and they also help each other.

Only three MI leaders explicitly noted the importance of instructional moves to support collaborative culture. For example, Mateo said:

> What I find out from my experience here is when the students come the first time, they don't talk. So the first thing I do is some breaking the ice, small activity, memory activity between all the students [so] that they remember the names for each one . . . The final project, I put it in teams [of] two, three people. . . . because working themselves is really hard, especially the coding.

Samantha talked about intentional mixed-ability grouping to support the goal of mutual guidance and attributed the idea to conversations with her peers in the community of practice, saying:

> I wanted it to be groups of three or four so that they can evenly divide work, discuss amongst themselves. I tried to have one person in, or at least have either more experience with biology in each group, more like lab experience, like maybe it was their second year at (CCC) rather than their first year, just so that they would kind of be able to share their background. Also, spreading apart the people who did have microbiology experience so that other groups could benefit from that, and they could help and guide the other students that didn't have experience.

In addition to leader interview and survey data, we used observation data to determine how collaborative the MIs were in practice.

Group structure during observations was categorized in five ways: individual, in which students were working by themselves; small group, in which students were working in groups of 2–5; large group, in which students were working in groups of 6 or more; whole group, in which all of the students were working together or engaged in discussion; and other. From our observations of the

MIs, it does appear that some leaders shifted the structure of their MIs to increase collaborative structures. Mateo began with an MI that was entirely individual work. However, in the next MI we saw an increase in whole group structure, a drop in individual structure, and the first implementation of small groups. Through Mateo's next seven MIs, a variety of group structures were implemented, and in his most recent MI, over 50% of the observed time was spent in small groups. This pattern is shown in Figure 2.

Unfortunately, the observation data was interrupted by the COVID pandemic, when all micro-internships were moved online for a period. Many leaders had never facilitated fully online, and a combination of these challenges and observational constraints made it difficult to identify patterns from these data.

Design principle 3: Authentic culminating product

MI leader comments related to Design Principle 3 focused primarily on engaging students in STEM practices and developing new technology-based skills (nearly 70%). This is unsurprising, given that most MI leaders stated their goals for MI students were to develop and strengthen these skills. Among them were the following stated goals, which all came from the faculty surveys:

- [The goal is that] students will engage first and foremost in mathematical modeling, and will experience modeling from the "brainstorming" stage, through design, through implementation in code … They will learn the basics of R programming and will be able to create basic R functions and operations by the end of the MicroInternship. Through the modeling exercises, students will see the effect of governmental policies on economic outcomes, and will begin to see policy as a tool for producing desirable outcomes. -Andrew
- [The goal is that] students will learn to read schematic diagrams and program an Arduino board to design and assemble small projects. - Mateo
- [The goal is that] the students will be trained in disease modeling, parameter estimation, analysis, optimal control theory, and computer programing and simulations. -Ham

In addition to these two subcategories, about 20% of MI leaders' comments related to their goal of students feeling ownership of their MI projects. Many of them described their goals for students to write and submit papers to scientific journals or present their work at science conferences:

- Students will produce charts, tables, and graphics that illustrate the influence of governmental policy on their economy, and will write a portion of a paper. Each group will write a portion of the paper, and the contributions from each group will be combined into a paper for publication. - Andrew
- I took two students [to a science conference]. One of them presented, and the other, he worked to prepare the presenting student. They were in the same class together. And that was a great experience for them, and for me. -Jake

Other MI leaders noted a sense of agency and ownership proffered by having a culminating product:

- Students will see a fully-functioning power supply assembled by them and that it can be used on different projects. Also, students will see that they can build a small equipment, and that later they can build or design a bigger equipment using the knowledge learned on this micro-internship. -Mateo
- I wanted them to kind of think of math and science as a creative endeavor where they have a project that … they've taken ownership over it and want to see it through to the end and want to see how their design produces some result or how their design produces their end product. -Andrew

Leaders made fewer than 10 comments related to the other aspects of Design Principle 3.

Collaboration, professional learning, and mentorship

Almost all of the MI leaders spoke about the relationships that the community of practice supported among faculty, either in focus groups, surveys, or interviews ($n = 12$). Here is an example from Rodney:

> Yeah, it's nice being associated with a group of same-minded people that work together for producing more successful students ready for beyond school. It's nice that we have that same direction, same goal. And then again, we constantly learn from each other and it's a sort of camaraderie that it's nice to have people you know, outside your typical workday. A break from just seeing students, a break from seeing staff, the break of, again, colleagues doing the same thing.

For most MI leaders, this was one of the first opportunities they had had in this context to engage in a sustained conversation about pedagogy with their peers, sharing ideas and experiences. Across data sources, MI leaders made it clear how productive this space became for them ($n = 8$). Here is an example from Samantha:

> I think the micro-internship community practice was really helpful, because we [were] able to get together and we got to talk about our ideas and things. We were able to collaborate. Creating a structure from that and being able to share that with other people kind of helped solidify my basic structure for micro-internships.

What made these spaces particularly supportive was the opportunity to engage in productive discussion with peers ($n = 7$). Jake spoke about this at length in his interview:

> Yeah. I think just in general it was great to get ideas from these community of practice meetings. It was great to get ideas for the next semester with our monthly meetings. That collaboration, or interaction, led to quite a bit of good ideas and improvements on what I was trying to do. . . . And so you make those improvements based on your own experiences, the student experiences, but also based on input from other faculty. Just going to the monthly meetings and hearing that somebody does this, and I'll make a mental note that, oh, I need to do that. Or I need to add this. I think the grant was good in that regard, I have closer connections with some of the faculty. Well, with all the faculty that routinely participate in the grant, I've made closer connections with them.

MI leaders also highlighted the opportunity to receive professional learning as part of the intervention. Samantha in particular really emphasized the role of the workshops, and the workshop leaders:

> I think the first workshop was so huge for all of us . . . [it] really helped us put on that thinking hat where we were like, "Oh, this is working. We can add these other things that we learned." So I think that also helped me change my outlook on how classes are run and how to make things more collaborative for students as well, and how to engage them more, and how to give them advice for when I'm helping them, like even now in classes.

Other MI leaders spoke about the role of mentorship, like in this quote from Mateo:

> It's learning from them . . . I'm . . . not a full time teacher . . . . So learning how to talk to the students. . . Also, when we have this training here, what are the goals, how we should do it. I think all these little details help me how to approach the students here. Because probably I'm one of the [MI leaders] here that has more experience in these micro-internships, because I've been doing this since this program started. I help other MI leaders here . . . Just last week, I talked to two MI leaders and I showed my flyer, I showed what I'm doing here, and they were happy. Says, "Thank you very much because that's the information we need." But I try to observe and apply what for other people is successful.

Not only did MI leaders find the intervention powerful for affecting their practice in the context of leading a micro-internship, several MI leaders also described applying ideas they learned in this space to their regular classroom teaching. When asked about the impact of the intervention, Jake explained:

> As an instructor, those are very helpful. Because each, like I said, month or in the summer, you're introduced to new ways to look at things and present, and to get students to interact. Professionally as a teacher, I think all of those little tidbits or ideas, those make their way into the classroom somehow. It's been helpful that way.

These quotes highlight the power of providing spaces like the summer workshops and ongoing community of practice meetings for collaboration, professional learning, and peer-to-peer mentorship.

Discussion

Next steps

We plan to analyze data collected by the project on the impact of this approach on student learning outcomes to determine whether or not this approach is effective in improving student learning. We also hope to obtain funding to conduct a more controlled study of micro-internships that is not interrupted by the COVID-19 pandemic, to study the impact on practice. This study would help us to determine how effective this approach is in a more normal setting.

Going forward, we hope to utilize an ongoing community of practice structure to focus on classroom pedagogy. CCC science courses are a key leverage point for nurturing the brilliance and potential of their diverse student populations (Espinosa et al., 2019). Engaging culturally and linguistically diverse students in meaningful and coherent learning in micro-internships is a great start, but doing so in the classroom could have significant impacts on both academic and non-academic student outcomes for a larger population of students. (Estrella et al., 2018; Miller & Krajcik, 2019; Roth et al., 2011, 2019; Schneider et al., 2016; Wilson et al., 2018).

Conclusion and implications

This study describes an intervention that made an impact on busy faculty, and the power of the resulting community to affect practice. It revealed that faculty do not get many opportunities to work in these types of facilitated peer communities. This is unsurprising, given the myriad constraints on CCC faculty time as they navigate institutions with fewer resources, heavy teaching workloads, and a growing reliance on adjunct workforce. But it is also problematic, given the research on how important it is for faculty and staff to engage in ongoing self-reflection, receive peer support, and make a commitment to research-based pedagogical shifts in order to support student learning and growth.

In the face of these criteria and constraints, we need to create more spaces for community college faculty to have conversations about pedagogy in a structured, ongoing way. These spaces need to be tailored to the needs of the student population at the community college to ensure that the impact on pedagogy is (a) responsive to students and (b) aligned with repertoires of practice research has shown to be culturally aligned to local communities. The micro-internship program described here allowed that within a narrow context, for a select number of faculty and students. But we believe that providing space for this at an institutional level could transform pedagogy in STEM community college classrooms, and support a much-needed transformation of our STEM workforce and traditional STEM culture, particularly at HSIs, which represent a key leverage point for nurturing the brilliance and potential of their diverse, Latine student populations.

One way to create these spaces is to provide funding for faculty to spend time developing and participating in programs like this one, and to attend conferences and workshops on pedagogy. It is also important to provide time for faculty to collaborate on teaching and learning initiatives. Our participants made it clear how valuable the time they spent in workshops and meetings for this project was to them, but ongoing constraints on their time and effort require community college leaders to be intentional in how to build those opportunities in structurally. This is hard in the current context, and is a strong argument for not relying so strongly on an adjunct workforce. Full-time faculty are more likely to have the time to engage in programs like this one, and have the opportunities to engage with their peers, forming relationships, and exchanging ideas. Adjunct faculty, on the other hand, are often in and out of the classroom too quickly to interact with their peers, and are not funded to participate in professional committees, training, or communities of practice.

Transforming pedagogy in STEM community college classrooms is essential to ensuring that all students have the opportunity to succeed in STEM fields. Traditional pedagogical approaches may not effectively serve all students equally. Programs like the one described here can support the use of strategies such as active learning, collaborative learning, and problem-based learning, which have been shown to increase engagement and success rates among diverse student populations (Oliván-Blázquez et al., 2023; Park et al., 2017; Salazar, 2020). Higher engagement should lead to higher retention rates and increased success in completing STEM degrees which ultimately will lead to greater diversity in STEM, and thus to a better future for our communities.

Notes

1. The term Latine is used as an ungendered alternative to Latino/Latina encompassing anyone born in or with ancestors from Latin America and living in the United States. The neutral e ending is preferred over the commonly used x because it is more coherent with existing patterns in the Spanish language.
2. The term non-male is used here to include women and non-binary people.

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