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A SHORT TEACHING RESIDENCY SPANNING 1,657 MILES

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In scientific disciplines, most postdoctoral fellowships focus on research training. Postdoctoral fellows ("postdocs") develop research expertise and research projects that they will use in future independent faculty positions. This research focus often precludes opportunities for undergraduate teaching. However, most academic faculty positions require faculty to teach at the undergraduate level. The result is that many postdocs are exceptionally well-qualified to meet the research expectations of future faculty positions, but lack experience and training in innovative and evidence-based undergraduate teaching strategies. Training in evidence-based teaching approaches can result in two tangible outcomes. First, the quality of applications by the postdocs for tenure-track faculty positions at institutions with substantive teaching expectations can be improved. Second, we can anticipate stronger alignment of teaching and learning expectations between new faculty and their undergraduate students. There are many programs that provide training in teaching to early career researchers. We describe the design and implementation of a mentored teaching experience that faced some unique challenges, including a large geographic distance between the postdocs and the teaching mentor and teaching site. We describe how we addressed the challenges, what the benefits to various stakeholders have been, and the key elements that contributed to the success of the program.

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THE CONTEXT OF OUR MENTORED TEACHING PROGRAM

The Fred Hutchinson Cancer Research Center (the Hutch) and New Mexico State University (NMSU) have had a long-standing partnership funded through the National Cancer Institute since 2002. The overall goals of this partnership are to increase minority participation in cancer and cancer health disparities research, and to build cancer research capacity at NMSU. As part of this program, we agreed that part of enhancing research capacity among participants in the program was to ensure that trainees had appropriate experiences to advance their careers. These experiences include a summer research internship at the Hutch for NMSU undergraduate students and mentored laboratory and public health research experiences for undergraduate and graduate students and postdocs in funded research programs at both institutions. We also made the conscious decision to provide training in evidence-based teaching-specifically *Scientific Teaching* (Handelsman et al., 2004) to postdocs at the Hutch. The Hutch supports approximately 230 postdocs, each reflecting diverse career goals, including positions in the biotechnology and/or pharmaceutical industry, research institutes, doctoral-granting institutes as well as primarily undergraduate institutions. Many (if not most) postdocs seek research experiences at the Hutch due to the reputation of the Hutch and individual faculty researchers. The Hutch has a robust career development program that supports postdocs entering careers in academia, industry and research-related fields.

While the Hutch has abundant resources to support postdocs interested in academic careers at research universities, it was seeking an opportunity to further support postdocs interested in pursuing faculty positions at primarily teaching universities. As the Hutch is a research institute, and does not offer undergraduate courses, there are limited opportunities for Hutch postdocs to gain undergraduate teaching experience. As teaching experience is critical to secure teaching-intensive positions, and as teaching experience may help postdocs evaluate the pros and cons of a research-focused vs teaching-inclusive position, the lack of teaching experience at the Hutch may hinder postdocs from exploring and attaining academic positions with an emphasis on teaching.

PARTICIPANT	CONTRIBUTION	BENEFIT
Hutch Postdocs	Content expertise to NMSU undergraduates	Mentored teaching experience with informal feedback and formal student evaluations
NMSU Faculty Mentor	Individual mentoring in Scientific Teaching to Hutch postdocs	Experience in mentoring (in teaching)
NMSU Undergraduate Students	Provide evaluations of teaching to Hutch postdoc	Taught by content area experts

TABLE 1. Contributions and benefits experienced by program participants.

FIGURE 1. NMSU's Technology-Enhanced Active Learning Classroom. Top (a): Instructor console in the middle of the room. Photo courtesy of Brandon Gallaher (used with permission). Bottom (b): Each student table has a flat screen monitor. Photo courtesy of Brandon Gallaher (used with permission).

Thus, despite the excellent postdoc training climate at the Hutch, there was a gap in terms of undergraduate teaching experience. The partnership between the Hutch and NMSU presented an excellent opportunity to design a mentored teaching experience for Hutch postdocs at NMSU. At the time the program was initiated, this was the only mentored postdoc teaching program available to Hutch postdocs (there was not a similar program available in Seattle). As we felt that the in-person teaching experience was critical, we were necessarily challenged to overcome constraints of distance between the partnering sites.

As part of the research and training partnership between the Hutch and NMSU, the authors had already collaborated on the design and development of an upper division course on cancer for undergraduates at NMSU (Shuster and Peterson, 2009). In the first offerings of this course, we used video teleconferencing technology to "host" one or two guest lecturers from the Hutch each semester. These guest lecturers were Hutch faculty, with a wealth of experience on each topic. The video teleconferenced seminars were highly rated by students, suggesting that "expert knowledge" was valued by students. However, this interaction was somewhat "one-sided" in terms of mutual benefit. NMSU students in the Introduction to Cancer course clearly benefitted from the expertise, but the Hutch faculty members giving the guest lectures did not experience obvious benefit. As the funding mechanism valued mutually beneficial partnerships, we considered ways in which we could expand the Hutch expert model so that both NMSU and the Hutch benefitted. Our model of using Hutch postdocs as content area experts in the NMSU Introduction to Cancer course was intended to provide several mutual benefits (see Table 1).

Between 2008 and 2016, 12 Hutch postdocs were accepted into the Cancer Teaching Fellows (CTF) program and had mentored teaching experiences at NMSU (we did not run the program in Fall 2012 and Fall 2013). There were between one and three postdocs in the program each year (all teaching in the fall semester). The teaching experience was with the same NMSU faculty mentor, who had experience in using

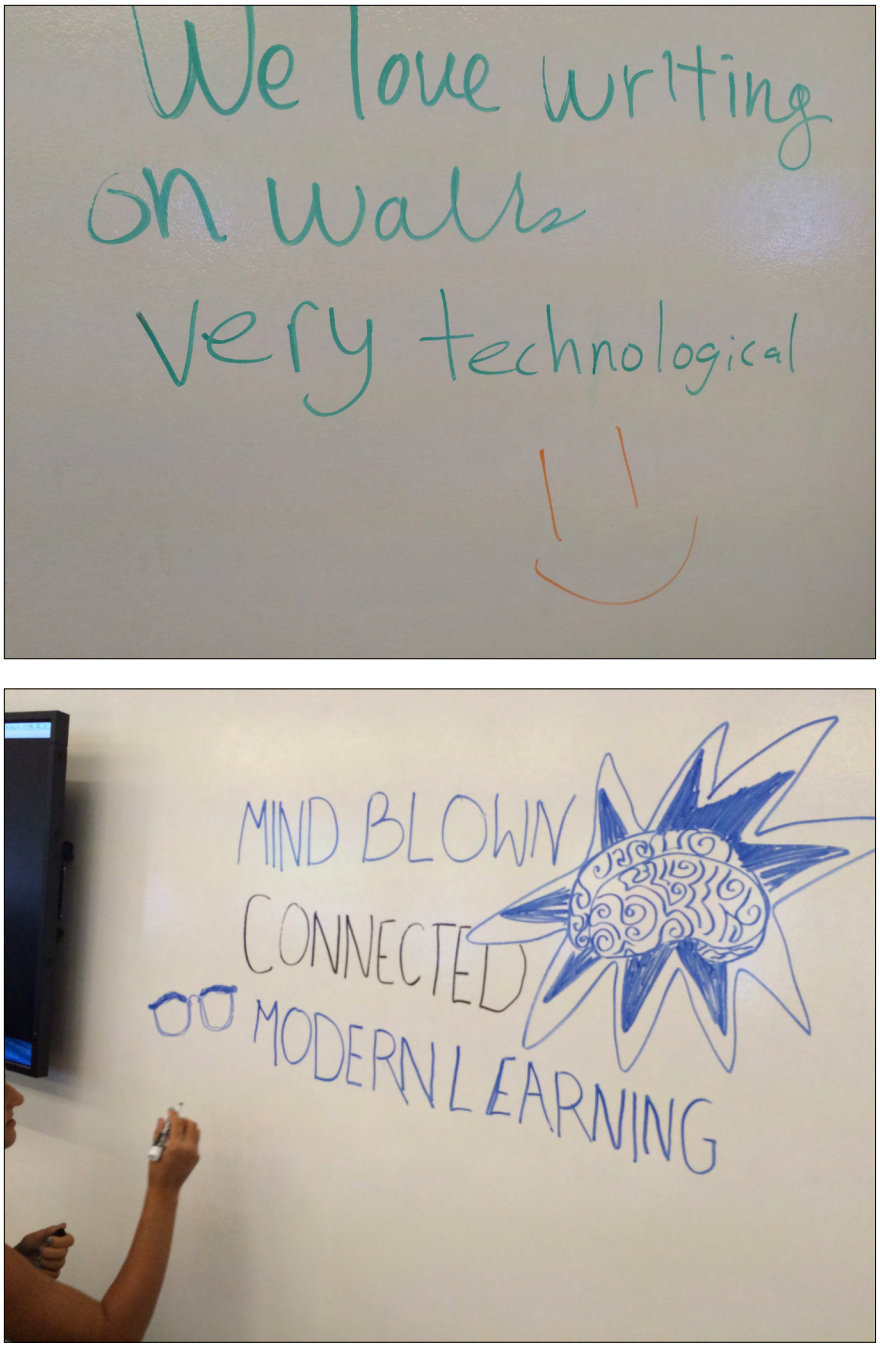


FIGURE 2. Student 1st-Day impressions of the TEAL Classroom (as written on the walls). Photos by Michèle Shuster.

Scientific Teaching, and in mentoring grad students, postdocs and faculty in using *Scientific Teaching*. The first 10 postdocs all taught in the NMSU Introduction to Cancer course. This was a strategic decision, as it allowed the postdocs to select a cancer-related topic for their week of teaching, ensuring that they would be comfortable with the content. In Fall 2015, the NMSU faculty mentor was teaching two sections of an introductory biology course in a newly built technology-enhanced active learning classroom (Beichner, 2014). This is a classroom model in which students sit at round tables (9 students per table) on a flat surface (there is no tiered seating). The instructor console is in the center of the room, so that there is no front or back of the room (see Figure 1) (Cotner, Loper, Walker & Brooks, 2013). Each student table has its own flat screen monitor mounted on the adjacent wall or an adjacent stand, so that every student at every table has an unobstructed view of material being presented. At NMSU, all the walls of the classroom are painted with whiteboard paint, allowing students to draw and graph and share ideas on their wall space. Between the round tables, which naturally foster student discussions and interactions, and the whiteboard painted walls, student interactions and thinking become expected and transparent, both for students and instructors. Interestingly, students instinctively appreciate the affordances of the room, as demonstrated by thoughts they wrote on the walls on the first day of class (see Figure 2).

As Introductory Biology in the technology-enhanced active learning classroom was the only course being taught by the NMSU mentor in Fall 2015, this was the course and venue for the CTF in that semester. In this case, both the course (introductory biology) and the room were new to the CTF experience and presented unique challenges. Specifically, there are limited opportunities to teach specialized topics relevant to the CTF's research in an introductory course, and the demand to use active learning (and to limit lecture) is particularly pronounced in this classroom environment.

The CTF prepared and delivered an interactive lecture and a case study activity as part of their teaching. They were able to structure class meetings to facilitate student-student and student-instructor interactions in a class with approximately 100 students, and to address relevant content at a level appropriate for the students. Based on this successful teaching experience in Fall 2015, the Fall 2016 CTF was given the choice to teach in the introductory biology course in the active learning classroom, or in the upper division introduction to cancer course in a traditional lecture room. They chose to teach in the introductory course in the new classroom, as they felt that this would

prove to be a more useful teaching experience for their future career.

HOW OTHER MENTORED TEACHING EXPERIENCES INFORMED THE DESIGN OF OUR CTF PROGRAM

As part of our design and development process, we explored other programs designed to provide postdocs (or faculty) with teaching experience.

A variety of formal programs provide training and professional development in teaching. These include the HHMI- and Helmsley-sponsored Summer Institutes on Scientific Teaching for faculty and future faculty (Yale Center for Teaching and Learning, 2018), the FIRST IV institutes for postdocs (FIRST IV, n.d.), the STEP program for postdocs (Price, n.d.), the NIH-funded IRACDA postdoctoral training program (Institutional Research and Academic Career Development Awards, 2018) and the University of Wisconsin-Madison DELTA program (Delta, n.d.) for future and current faculty. While each of these programs have unique goals and approaches, all seek to enhance undergraduate teaching. And while not all of them confront the challenge of geographic distance between mentees and mentors, many confront a separation (temporal and geographic) between the training/professional development experience and the actual teaching experience. We reviewed program websites and publications, and considered our own personal experiences in order to determine how to structure our program.

Based on our review of other programs and our own experience, we determined that the following elements needed to be addressed by our CTF program:

- Familiarity with the principles of Scientific Teaching
- Backwards Instructional Design
- Classroom Observations
- Classroom Teaching Experience
- Student Feedback (in the form of anonymous student evaluations of teaching)

The rationale for addressing each of these elements is discussed next. The logistics of how each of these was implemented is described as part of the design itself.

Familiarity with the Principles of Scientific Teaching

Scientific Teaching is a way of teaching that focuses on the "pillars" of active learning, assessment (formative and summative) and inclusivity (Handelsman et al., 2014). These pillars contribute to a classroom environment that is student-centered and designed to support success for all students. As Scientific Teaching is also a recognized approach to undergraduate education, postdocs who have familiarity with this approach should not only be able to effectively teach, but may be more competitive for academic positions based on demonstrated experience with Scientific Teaching.

Backwards Instructional Design

Backwards design is an instructional model in which instructors first consider what they want students to be able to do at the end of instruction- the learning goals or desired outcomes (Wiggins & McTighe, 1998). Instruction (lectures and learning activities) are then designed to align with and support development of student proficiency with respect to goals and outcomes. Alignment of goals and instructional activities is an important aspect of both Scientific Teaching and Backwards Instructional Design.

Classroom Observations

All postdocs have clearly experienced and successfully completed undergraduate science classes. In many cases these were classes taught by traditional lecture, and the postdocs may not have experienced active learning during their own undergraduate courses. Classroom observations thus provide an opportunity for postdocs to not only be exposed to active and collaborative learning, but to be exposed to it as a critical observer, rather than a student/participant. As an observer, postdocs can pay attention to the instructor, the instructional materials (e.g.,, slides and handouts), as well as student behaviors that can indicate student engagement. These kinds of "global" observations are generally not made by students in the course, but can be informative in terms of observing the impact of particular teaching and learning strategies on students and student engagement. These kinds of observations are also often challenging for instructors to make during their own lectures, particularly inexperienced instructors focusing on the logistics of delivery and timing, particularly when using active learning strategies for the first time. Thus, the opportunity to observe other instructors/classrooms permits critical observations and reflections that are not easily made as a student or as an instructor.

Classroom Teaching Experience

While there are many courses and workshops designed to teach prospective teachers how to teach (Summer Institutes, First IV, DELTA, as noted earlier), practical teaching experience is critical for effective teaching. Many programs that teach new strategies (e.g.,, case studies, Scientific Teaching) involve an on-site/in-class teaching experience (Wright, 2018, Yale Center for Teaching and Learning (2018)) or follow-up teaching (First IV). In our experience, even with instruction that emphasizes active learning strategies, inexperienced instructors often revert to traditional lecturing in their first teaching experiences if there is not a structure in place to provide on-going feedback during the planning and implementation of teaching.

Student Feedback (student evaluations)

While there is much debate about the value of student evaluations in evaluating teaching effectiveness (e.g.,, Hornstein & Law, 2017), student feedback can be very important in terms of self-assessment of teaching. For novice instructors, asking for specific feedback regarding pacing, clarity, and usefulness of various teaching materials (e.g.,, slides, prep assignments, homework, handouts) can prove to be particularly useful to inform future teaching experiences. As students are the focus of the teaching, their feedback should be sought and should promote self-reflection.

Formal student feedback is also a valuable element in a teaching portfolio for postdocs seeking an academic position with a teaching component. Summary student evaluations as well as reflections on those evaluations provide concrete evidence of formal teaching experience, a valuable commodity in a competitive job market.

CHALLENGES THAT HAD TO BE CONSIDERED IN OUR DESIGN

Travel and Time Away from Research

While we had identified several key elements to a successful mentored teaching experience, we faced several challenges that had to be addressed in our design. The key challenge was the geographic distance between the Hutch and NMSU. The distance led to other challenges, but the primary issue we needed to address was the distance. This distance prohibited face-to-face meetings, an extended period for classrooms observations, and time for the observations to inform the instruction. The distance also necessitated a short but intensive teaching residency, as it was impractical for the postdocs to be away from the Hutch for extended periods of time. As the postdocs had to travel to participate in the teaching residency, we used grant funds to pay for their travel, and provide a per diem for their accommodations in Las Cruces. We also felt that the travel and time commitment were substantial enough to both be potential deterrents to participation and to merit some kind of tangible recognition. As we had grant funding, we decided to offer a $1000 honorarium for each CTF. While none of the CTFs declined the honorarium, we did not get the impression that CTFs were participating solely for the honorarium (and some noted that they would have participated just for the experience). We thus feel that while the honorarium was a fair and appropriate thing to do, we suspect that it was not a critical factor in our design.

Timing of Preparation Relative to Observations and Teaching

In light of the geographic separation (which precluded frequent classroom observations over an extended period of time) the postdocs had to at least partially prepare their instruction before they carried out their observations. However, the instruction cannot be finalized until the postdocs have completed some classroom observations. This requires a fair amount of pre-residency preparation work, which in turn requires that the postdocs be both motivated and sufficiently organized to complete the prep work while still getting their research done. This also meant that all pre-residency communication had to be carried out by e-mail, phone or Skype, rather than in-person, face-to-face meetings.

As a result of the challenges and limitations noted above, the on-site residency was necessarily intense. The instruction (including any prep work, handouts, and assignments) had to be finalized during the first week of observations. This proved to be time-consuming, making it difficult for the postdocs to try to juggle research responsibilities (e.g.,, data analysis) with the expectations of the teaching residency. This raises one other important issue- that of how (or if) the postdocs' research progress would be affected during the two-week teaching residency. In order to ensure that the research mentors were aware of the experience and its possible implications on the research program, the research mentors were required to write a letter of recommendation for applicants from their labs.

Ultimately, our challenge was to design a meaningful mentored teaching experience with two weeks of "on the ground" time. The design of the program needed to provide a structured, mentored teaching experience such that CTFs will:

- Use principles of scientific teaching to develop their lectures
- Deliver effective lectures to a diverse population of undergraduate students
- Use their CTF experience in their future careers

DESIGN

Our design is summarized in Table 2. Details of each element are described in more detail next.

CTF Recruitment

We designed our recruitment strategy and application process to recruit postdocs who had a genuine interest in teaching and who stood to benefit from the mentored teaching experience. Postdocs who aspired to work in a biotechnology company, or a research organization with little or no teaching responsibilities were less likely to benefit in terms of successfully obtaining and then succeeding in an academic position that includes teaching expectations. As many postdocs do not start seeking academic positions until their 3rd of 4th year (often the time it takes to establish a robust research program), it also made sense to recruit and select postdocs who were closer to applying the teaching

CTF Selection (NMSU and FHCRC)	Preparation (@ FHCRC)	1st Week of Residency (@ NMSU)	2nd Week of Residency (@ NMSU)
~9 Months from Acceptance→ Completion			
March – April	**June-August**	**September-November**	**September-November**
Application • teaching interests • research interests • career goals • CV • letter of rec. Evaluation of • interest in academic position • potential to obtain an academic position?	Distance Model • frequent feedback from teaching mentor • select teaching topic • draft learning objectives • plan learning activities • flesh out framework	• Classroom observations • Refine framework • Finalize "lectures" • Practice teach to teaching mentor	• Teach • Prepare & deliver prep and follow-up assignments • Office Hours • Meet with faculty, department head

TABLE 2. Key elements of our design for a two-week mentored teaching residency for Hutch postdocs at NMSU. .

experience in the form of job applications (which require statements of teaching interest) and subsequent on-the-job responsibilities.

In order to make the expectations of having an interest in and expectation of teaching as part of their future career, we included the following text on an informational flyer and postdoc distribution list e-mails:

> *"Who should apply to participate in the Cancer Teaching Fellows program?*
>
> ✔ *Any Hutch post-doctoral fellow who is interested in gaining undergraduate teaching experience.*
>
> ✔ *Any Hutch post-doctoral fellow who is interested in pursuing a career at a university where undergraduate teaching is an expectation."*

The program overview page also noted: "Applicants will be selected based on their interest in teaching, as evidenced by participating in teaching at the Hutch or other institutions."

As noted earlier, given the intensity of the two-week on-campus experience, we needed some assurance that the postdocs would be able to be single-minded in their efforts during the residency, and not try to juggle extensive research demands with their teaching. For this reason, we decided to require that the research mentor write a letter of recommendation for each CTF applicant. This ensured that the research mentor was not only aware of the CTF program, but was fully supportive of the participation of their postdoc.

While a small fraction of faculty at the Hutch are reluctant to allow their postdocs to spend two weeks away from the bench, most of the faculty understand the inherent benefit that the CTF experience will give the postdoc to improve their teaching skills, which is an important skill for obtaining a tenure-track position at many institutions. As an independent research institution, there are few opportunities for formal teaching experience at the Hutch. In addition, gaining teaching skills at NMSU, a minority serving institution, is in alignment with the Hutch Strategic Goal of "emphasizing diversity and inclusion as core values, integral to all the work that we do." For those CTFs who have felt the need to do postdoc work while at NMSU, they have focused on data analysis, manuscript writing and grant writing. Hutch scientists have 24 hour global access to their Hutch work via a laptop and VPN internet connection.

Program information was provided on a Hutch website, which also included a link to the application itself, as well a one-page recruitment flyer that was posted on the Hutch campus and distributed to a postdoc email list. The one-page flyer provided a brief program overview, the eligibility criteria (U.S. citizen or permanent resident, as stipulated by the funding source), a link to the application and contact information for questions. The program overview website had more extensive information than the flyer, including dates of participation, program mentorship, information on compensation, travel and housing, as well as a link to the application, eligibility and selection criteria and contact information in case of questions.

CTF Application

The application packet reiterates the program information (overview, program mentorship, compensation, travel and housing, and eligibility criteria). It also provides sample course schedules (with dates and topics) for courses that the CTFs could teach in. The actual application form requests personal and demographic information (the latter is for reporting to the funding agency). In addition to this form, applicants are asked to submit a short (500 word) statement of research interests and career goals, a one-page statement of teaching philosophy and a CV. As many postdocs have not drafted a teaching philosophy statement, the following prompt is provided: "This statement should include your conception of teaching and learning, how you incorporate your teaching philosophy in the classroom, and a description of how you teach [how do you respond to different learning styles, help students who are frustrated, and accommodate students with differing abilities?]. Your statement should also communicate your goals as an instructor, and your corresponding actions in the classroom."

We used prior teaching experience as indication of genuine interest in teaching and in learning more about effective teaching. Despite the Hutch not offering formal courses, there are opportunities for postdocs to guest lecture in e.g.,, a Cancer 101 informal lecture/seminar series for Hutch employees, and/or to guest lecture in courses taught by many Hutch investigators at the University of Washington. Given the competitive job market which requires both evidence of teaching and competitive research, we did want to accept CTFs who were interested enough in teaching to have made even a modest effort to obtain some teaching experience, and reflect on it in the form of a short teaching statement. This provided evidence of motivation and a likelihood that the CTF would be willing to learn more about teaching and perhaps try something new while teaching. The actual amount of prior teaching or the quality of the teaching statement were generally not deciding factors when accepting CTFs into the program.

CTF Review and Selection Process

Since 2008, we have had 12 CTF participants in seven years. Early in the program, we had several applications each year (as many as 5). This may have been a reflection of the novelty of this program, and the fact that during the economic downturn, academic jobs were hard to obtain, making any competitive edge (such as the CTF teaching experience) an advantage. Due to the demand, we accepted two or three CTFs in each of the fall semesters from 2008-2011. In general, all the applicants were competitive. Consistent with our goals and stated criteria, we used evidence of teaching experience as a major criterion. We also considered their research record, as that would be an important driver of success in the academic job market. From 2014-2015, the number of annual applications dropped substantially (to between one and four), and we accepted one CTF per fall semester. We suspect that part of the reason for the decline in number of applications was a new program that provides mentored teaching experiences in the Seattle area, which became a local alternative to our program. However, despite the decline in number of applications received, we did not notice a change in the quality of applications. The quality of applications has remained high throughout the program. This suggests that postdocs who apply to participate in the CTF program at NMSU have a genuine interest in the program, which could be motivated by the opportunity for intensive mentoring, the immersion on a college campus, that nature of the courses to be involved in and/or the diverse student body.

CTF Pre-residency Prep Work

From 2008-2014, the CTFs all taught in an upper division introduction to cancer course. In Fall 2015, the NMSU teaching mentor was only teaching an introductory biology course for majors, which restricted the CTFs teaching experience to that course. In Fall 2016, based on the teaching mentor's teaching schedule, the CTF had the choice to teach in either the upper division intro to cancer course, or the introductory biology course. In this case, the CTF chose to teach in introductory biology. Regardless of the course being taught, the pre-residency preparatory work followed the same general steps and took place during the summer before their residency.

CTFs first committed to the general topic for their teaching, based on the course schedule. The choice of topic area was made by the CTF, based on their own interests in teaching and/or research. Once the topic had been determined, the CTFs worked to become content-experts in that area. This was to allow them to have sufficient expertise to be able to determine the most important concepts for students to be familiar with. This allowed the CTFs to then set between three and five learning goals and objectives for the students.

The CTFs then used backward design to develop a Scientific Teaching framework for their teachable unit (their week of instruction). They designed learning activities and assessments that aligned with the learning objectives, and considered diversity and inclusivity. One of the explicit guidelines was that the CTFs were not to prepare any lecture slides. They were encouraged to prepare lecture outlines, activities (including prep assignments, worksheets and slides), and to outline any lecture slides, but not to actually write lecture slides until after having observed lectures during the 1st week of their residency. Timelines were set for each major objective- topic selection, learning objectives, teachable unit outlines with embedded outlines for lectures and activities, and the teaching mentor prepared feedback on each deliverable. The goal was that the CTFs would arrive on campus with an outline for their Teachable Unit,

well-developed activities (including prep assignments, slides, handouts and follow-up questions), leaving final lecture slide development as an on-campus activity, to be prepared after the initial classroom observations.

1st week of the NMSU residency

The first week of the NMSU residency has two main objectives for the CTFs: (i) to observe as many classes as possible and (ii) to finalize the lecture slides and practice teach their teachable unit to the teaching mentor.

The CTFs observed several classes, including the teaching mentor's classes, introductory biology classes and upper division biology classes. The CTFs were asked to sit closer to the back of the classroom so that they could observe student behaviors and various classroom interactions (e.g.,, student-student and student-instructor interactions). The goal was to ensure that the CTFs observed a wide range of classes, based on level (introductory and upper division), instructor experience and teaching approach. The instructors who were asked if they were willing to have a CTF observe were all experienced faculty (we did not feel that a new instructor would be comfortable with an observer that they did not already know), and all used a variety of approaches from clickers, to in-class discussion and problem solving integrated into an interactive lecture approach.

After observing the class in which they would teach, the CTFs met with the instructor/teaching mentor to review their outline for their teachable unit. At this time, they begin to develop the slide presentation for their class meetings. They developed their slides using the same template and font as the instructor, to ensure that their class meetings have the same "look and feel" as the rest of the course. This minimized potential negative impacts of how students perceive "revolving" instructors in the course. The CTFs also finalized any prep assignments and other supporting documents (e.g.,, lecture outline, study questions) for posting on the course learning management system, and any class handouts for copying. Towards the end of the week (or over the weekend), the CTF practice taught their classes to the teaching mentor.

2nd week of the NMSU residency

During the 2nd week of their residency, the CTFs taught their classes in the mentor's course. They also prepared follow-up study questions (to post on the course management system) and exam questions. If the students handed in any work (e.g., a worksheet, graph or diagram), the CTF graded the student work. The CTFs also held office hours for students.

In addition to their teaching, the CTFs also met with faculty in the department and the department head. These meetings were intended to give the CTF an opportunity to learn more about faculty roles and responsibilities, work-life balance and tips for the job application process.

THE CTF TEACHING EXPERIENCES AND LECTURES

The CTFs were able to develop and implement classes that successfully incorporated active learning to support clearly articulated learning objectives. The faculty mentor sat in on

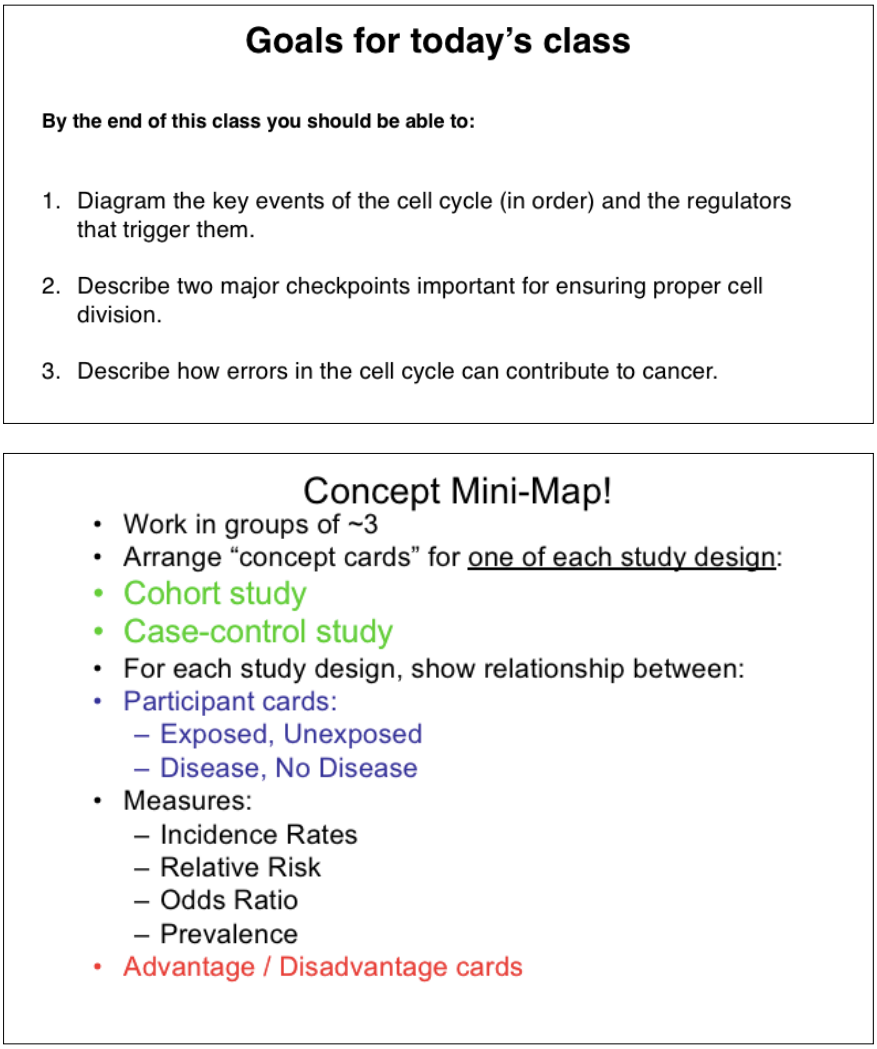


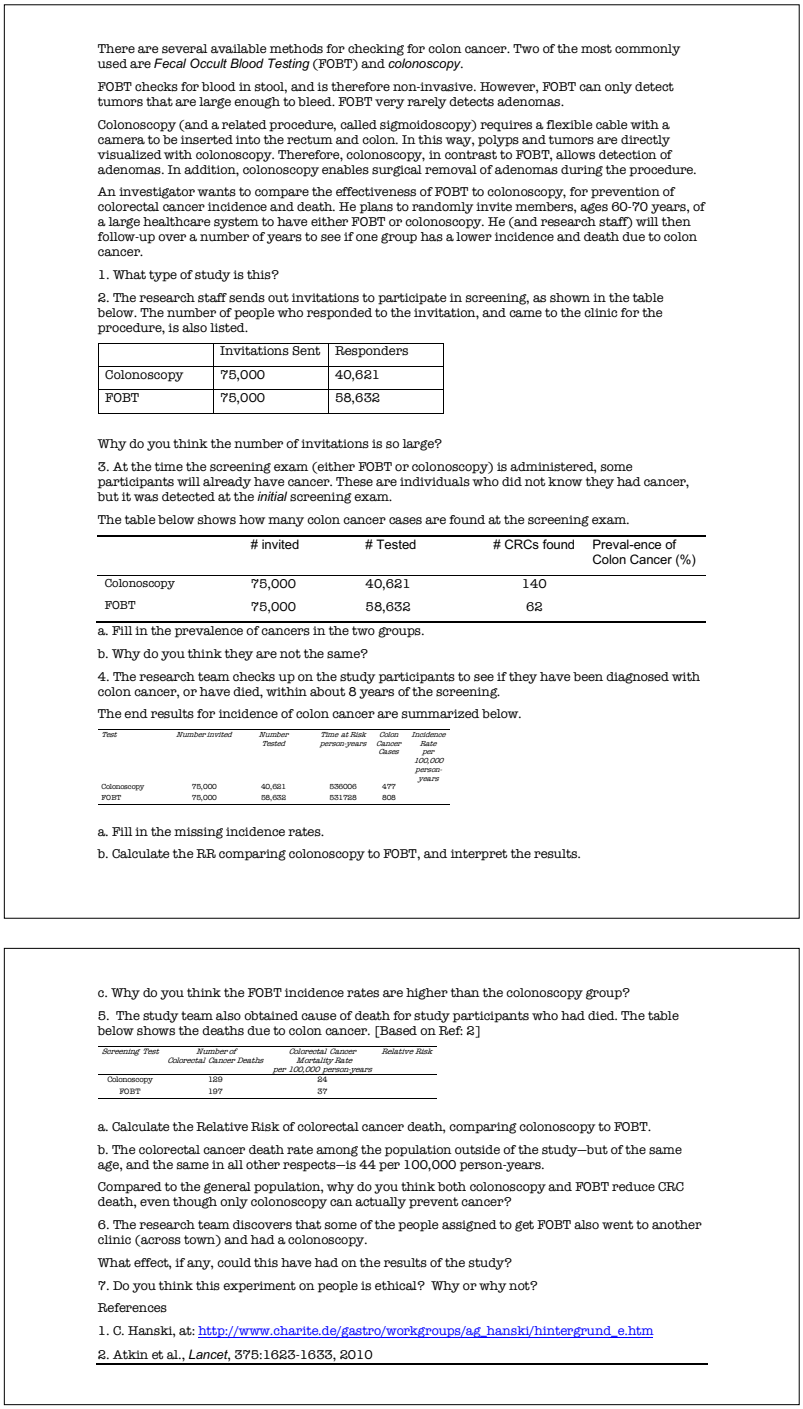
FIGURE 3. Example of CTF learning objectives (top) and a sample concept map activity from a CTF (bottom).

all the CTF lectures, so that they could provide meaningful feedback to the CTFs. However, the extensive prep work, observations and practice teaching was effective at ironing out many of these issues, minimizing the impact on students during class.

The CTFs all shared clearly articulated learning objectives with students for each class meeting. An example of learning objectives for a lecture on cell cycle regulation is shown in Figure 3 (top).

The CTFs successfully incorporated peer-reviewed case studies (e.g., a published case study on osmosis by the Fall 2016 CTF teaching in Introductory Biology (http://sciencecases.lib.buffalo.edu/cs/files/osmosis.pdf). Several CTFs also designed in-class "mini activities" to allow students to practice using relevant content. For example, one CTF designed a concept mini-map activity to reinforce various types of epidemiological studies (see Figure 3, bottom):

The same CTF also developed three in-class epidemiological case studies (breast cancer, colon cancer and liver cancer) so that students could reinforce and apply their knowledge of cancer epidemiology (see excerpt from the colon cancer worksheet in Figure 4):



There are several available methods for checking for colon cancer. Two of the most commonly used are *Fecal Occult Blood Testing* (FOBT) and *colonoscopy*.

FOBT checks for blood in stool, and is therefore non-invasive. However, FOBT can only detect tumors that are large enough to bleed. FOBT very rarely detects adenomas.

Colonoscopy (and a related procedure, called sigmoidoscopy) requires a flexible cable with a camera to be inserted into the rectum and colon. In this way, polyps and tumors are directly visualized with colonoscopy. Therefore, colonoscopy, in contrast to FOBT, allows detection of adenomas. In addition, colonoscopy enables surgical removal of adenomas during the procedure.

An investigator wants to compare the effectiveness of FOBT to colonoscopy, for prevention of colorectal cancer incidence and death. He plans to randomly invite members, ages 60-70 years, of a large healthcare system to have either FOBT or colonoscopy. He (and research staff) will then follow-up over a number of years to see if one group has a lower incidence and death due to colon cancer.

1. What type of study is this?

2. The research staff sends out invitations to participate in screening, as shown in the table below. The number of people who responded to the invitation, and came to the clinic for the procedure, is also listed.

	Invitations Sent	Responders
Colonoscopy	75,000	40,621
FOBT	75,000	58,632

Why do you think the number of invitations is so large?

3. At the time the screening exam (either FOBT or colonoscopy) is administered, some participants will already have cancer. These are individuals who did not know they had cancer, but it was detected at the *initial* screening exam.

The table below shows how many colon cancer cases are found at the screening exam.

	# invited	# Tested	# CRCs found	Preval-ence of Colon Cancer (%)
Colonoscopy	75,000	40,621	140	
FOBT	75,000	58,632	62	

a. Fill in the prevalence of cancers in the two groups.

b. Why do you think they are not the same?

4. The research team checks up on the study participants to see if they have been diagnosed with colon cancer, or have died, within about 8 years of the screening.

The end results for incidence of colon cancer are summarized below.

Test	*Number invited*	*Number Tested*	*Time at Risk person-years*	*Colon Cancer Cases*	*Incidence Rate per 100,000 person-years*
Colonoscopy	75,000	40,621	536006	477	
FOBT	75,000	58,632	551728	808	

a. Fill in the missing incidence rates.

b. Calculate the RR comparing colonoscopy to FOBT, and interpret the results.

c. Why do you think the FOBT incidence rates are higher than the colonoscopy group?

5. The study team also obtained cause of death for study participants who had died. The table below shows the deaths due to colon cancer. [Based on Ref: 2]

Screening Test	*Number of Colorectal Cancer Deaths*	*Colorectal Cancer Mortality Rate per 100,000 person-years*	*Relative Risk*
Colonoscopy	129	84	
FOBT	197	37	

a. Calculate the Relative Risk of colorectal cancer death, comparing colonoscopy to FOBT.

b. The colorectal cancer death rate among the population outside of the study—but of the same age, and the same in all other respects—is 44 per 100,000 person-years.

Compared to the general population, why do you think both colonoscopy and FOBT reduce CRC death, even though only colonoscopy can actually prevent cancer?

6. The research team discovers that some of the people assigned to get FOBT also went to another clinic (across town) and had a colonoscopy.

What effect, if any, could this have had on the results of the study?

7. Do you think this experiment on people is ethical? Why or why not?

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1. C. Hanski, at: http://www.charite.de/gastro/workgroups/ag_hanski/hintergrund_e.htm

2. Atkin et al., *Lancet*, 375:1623-1633, 2010

FIGURE 4. Excerpt from the Colon Cancer Epidemiology Worksheet.

LEVERAGING THE CTF EXPERIENCE

All 12 CTFs have completed their postdoctoral fellowship at the Hutch. At the present time, five have positions that have a teaching component. Three are faculty members at universities, and two are high school teachers. The remaining CTFs have positions at biotechnology companies.

Upon return to the Hutch, CTFs have access to a professional development program, Ivory Tower Quest, that is designed to assist our postdocs in obtaining tenure-track faculty positions. Postdocs receive expert guidance from the application phase to the negotiation phase, including individualized coaching, panels of experts, examples of successful proposals, and opportunities for practicing research and chalk talks. From 2010-2017, 27% of all Hutch postdocs obtained tenure track faculty positions, followed by industry (24%), non-tenure-track academic positions (15%), and another postdoc (15%).

STUDENT VOICES

The students were able to complete student evaluations of the CTFs at the end of the teaching week. Students "graded" the CTF instructor (on an A-F scale) for several standard items. Overall, the CTFs earned a high percent of A ratings for each item (Figure 5). Between 65% and nearly 90% of the students gave the CTFs an "A" grade for all of the standard items. When expressed as a GPA, the CTFs earned high "GPAs" for each item on the student evaluations (see Figure 6).

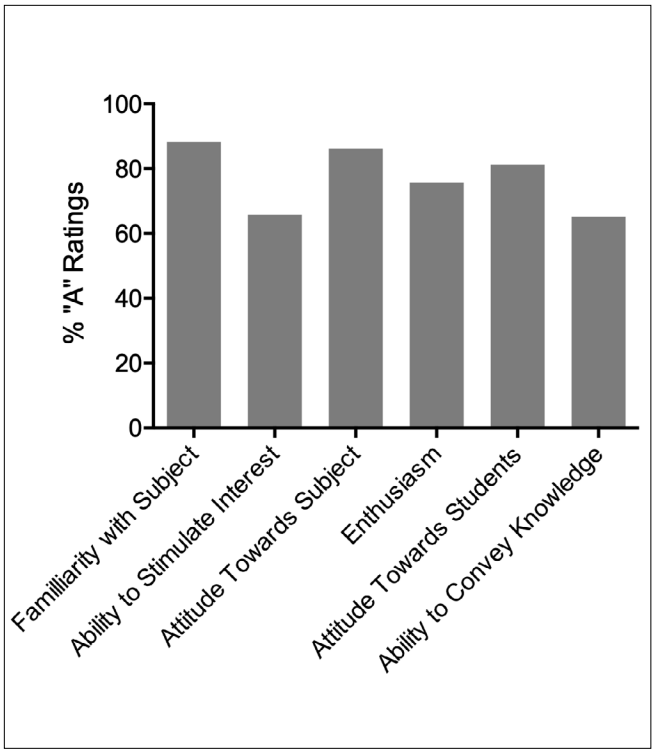

FIGURE 5. Average percent of "A" ratings received by CTFs on each Student Evaluation Item.

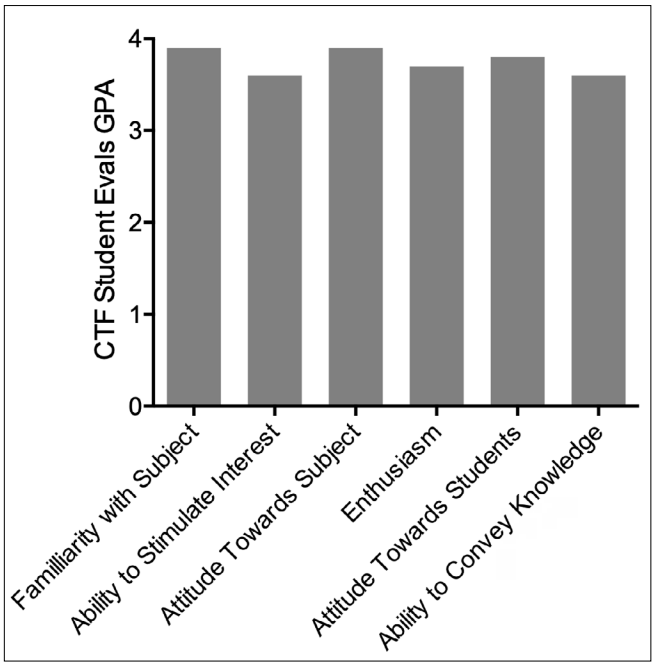

FIGURE 6. Average "GPA" (weighted average) of ratings received by CTFs on each Student Evaluation Item.

Clearly (and not surprisingly, given the expertise of the CTFs) the students rated the CTFs highly on their familiarity with the subject matter, and their attitude to the subject (both had an average GPA of 3.9 on a 4-point scale and over 85% A ratings across all CTFs who taught in the upper division Introduction to Cancer course). Student open-ended comments often noted that they appreciated both the specific material presented by the CTFs and the expertise of the CTF:

> *"I really enjoyed the material and appreciated her expertise in the subject."*
>
> *"Great subject choice"*
>
> *"Interesting material"*
>
> *"Keep up the wonderful enthusiasm. I especially enjoyed the personal attachment you have with the subject, and I'm so glad you shared that with us."*

This suggests that we should continue to allow the CTFs to choose their teaching topics so that they can be as comfortable as possible with the material. It also suggests that students appreciate the specific content and expertise brought to the course by the CTFs, particularly when the CTFs were able to integrate their own research into their lectures.

The CTFs also received high ratings for their attitude to students (86.1% A's and an average GPA of 3.8). Many students wrote open-ended comments that reflected this:

> *"She did very well conveying the information to the students and attitude was great, making it easy to learn from her"*
>
> *"It could have been dull, but [CTF] related it well to us non-researchers"*
>
> *"Keep up the enthusiasm and interaction that challenges the students- its refreshing"*
>
> *"[CTF] did a really good job. Got me really interested and didn't lose my attention"*
>
> *"great people skills"*
>
> *"I appreciated her willingness to go back and re-explain and answer questions"*

This is particularly important, as it suggests that the CTFs were able to establish a rapport with the students in only two or three lectures. We suspect that was in least in part due to the fact that following the principles of *Scientific Teaching* (setting learning objectives, aligning active learning with those objectives and considering inclusivity) allowed the CTFs to demonstrate that they wanted the students to succeed.

This is reinforced by several student comments:

> *"I enjoyed his enthusiasm and how he got everyone involved"*
>
> *"Appreciated the in-class activities"*
>
> *"I really enjoyed the class participation activities and actually talking about the topics (rather than just listening to lecture)"*

We also suspect that their smooth integration into the class was facilitated by their observations, and the fact that they

followed the general "model" for the course. For example, the CTFs used similar fonts and organization for the slides as the instructor, posted lecture outlines that were similar in format to the instructor, and strove to pace their class meetings in a way that was similar to the instructor.

In terms of *future improvement*, the students rated the CTFs somewhat lower for the ability to stimulate interest (65.5% As/ 3.6 GPA) and the ability to convey knowledge (65.2% As/3.6 GPA). It is challenging to identify potential underlying issues in this regard- while CTFs have high ratings for familiarity with and attitude to the subject matter, there seems to be a gap in how this translates to the ability to stimulate interest and convey knowledge about the subject matter, as perceived by the students. The lower ability to convey knowledge ratings may be related to the pace (often a little fast for an undergraduate lecture as compared to a scientific seminar) and the inexperience /lack of prior practice in explaining complex concepts to undergraduates. We can attempt to address this through the prep- ensuring that the CTFs are not trying to tackle too much, and through the practice lectures- ensuring that the CTFs practice all of their explanations, and that the explanations do not rely on background knowledge that the students are not likely to have. The lower ratings for ability to stimulate interest may be a function of a disconnect between what the postdocs find inherently interesting (basic research questions), and what students find interesting at this stage (practical, clinical and translational applications of basic research to human health).

UNANTICIPATED CHALLENGES AND LIMITATIONS OF THE DESIGN

Pre-Residency Preparation

While our pre-residency preparation had been carefully designed to ensure that CTFs would arrive on campus with a fully developed teachable unit (including learning objectives, an outline for their teaching, well-developed in-class activities and any student prep assignments), it became clear that the design did not adequately account for the challenges that the CTFs would face to dedicate sufficient time and effort to complete all aspects of the planned prep work. The design asked for a substantial amount of preparation for the teaching experience while the CTFs had to continue to meet the expectation of their research mentor and their own goals for their postdoctoral research. This issue (the design perhaps asking too much of the CTFs in terms of prep work) was also reflected in the failure of CTFs to fully integrate into the course, despite the attempt to accomplish this by including all of them in the course management system.

As noted by one CTF:

> *"Although [teaching mentor] did her best to loop me into the course web pages, lecture/activity materials, and some of the curriculum discussions ahead of time, for someone living 24/7 in a research lab in Seattle, I think I simply had no way to fully appreciate what was happening in the undergraduate classrooms of NMSU until I got there—which is why the "residency" was such a useful experience!"*

The prep work was presented to the CTFs as one "packet", with deadlines to share distinct deliverables with the teaching mentor (e.g., the first deliverable was 5 key concepts for students to remember in 5 years; these became the basis for writing formal learning goals and objectives). The teaching mentor would then review the materials and provide feedback, so that the feedback could be used as the CTF continued their prep work. As we have realized, this was a demanding aspect of the design, which ultimately shifted much of the work to the 1st week of the residency, making that week more intense for both the CTF and the teaching mentor.

Moving forward, we plan to have more regular (scheduled) check-ins by phone or Skype, in addition to the deadlines and the invitation for the CTF to contact the teaching mentor as questions arise during their preparation. This may make the preparation a bit easier, as ideas can be discussed as they are being developed. However, we recognize that the CTFs necessarily need to put their research first, so will focus the preparation phase of the design on

- Developing concrete learning goals and measurable objectives
- Becoming familiar with a variety of active learning strategies and beginning to select those that will help students meet the goals and objectives
- Outlining their teachable unit (without formalizing slides or activities)

We would also consider either Skyping the CTFs into one or more lectures, and/or recording one or more lectures for the CTFs, so that the CTFs can get a sense of the classroom dynamics prior to arriving on campus.

Logistics of Lectures

We recognized that the design was probably unable to fully prepare CTFs who were new to classroom teaching for a perfectly timed and executed first lecture, particularly given the incorporation of active learning strategies. We intentionally planned practice teaching sessions into the design and discussed strategies for managing time and logistics during these practice sessions. Specifically, the design of these practice teaching sessions centered on the need to be flexible, aware of students' questions, and responsive to the classroom "environment" (e.g., being aware of whether students were keeping up or not) as the lecture progressed. During the CTF lectures, students had been specifically

asked to let the CTFs know if they had any questions, and the students appeared to feel comfortable about asking for clarifications. The CTFs were likewise very responsive to these requests, willingly stopping, going back and re-explaining points. The CTFs were also willing and enthusiastic to implement the active learning activities that they had designed. As with many newly designed activities, the most challenging issue was anticipating the timing of the implementation, as we had tried to anticipate in the practice teaching sessions. During the practice teaching sessions, the CTFs were encouraged to be prepared to stop an activity early or skip a section in the interest of time. This allowed them to have an "exit strategy" for an activity, that would not compromise the rest of their lectures if an activity could not be completed. In many ways, the practice lectures to the teaching mentor ended up being far more valuable than we had originally anticipated. While they were not delivered in "real time" (i.e., at the planned teaching pace), many opportunities to consider explanations, student prior knowledge and transitions came up. The teaching mentor was also able to anticipate potential issues that could arise with students, so that the CTF could consider key points at which to stop and check in with students (e.g., with a clicker question or other type of formative assessment).

As noted by one CTF:

> *"…it was a busy 2 weeks, in which I was fully immersed in the process of preparing for the lectures, but when it came time to deliver them, I was confident they would go smoothly—and they did!"*

Non-Uniform Grading Experience

One limitation of the design is that not all CTFs were able to experience grading. This was mostly because the course syllabus and grading scheme as determined by the course instructor had a fixed and pre-planned number of graded tests and assignments that did not coincide with the CTFs' teaching. To a certain extent, this was intentional. The CTFs already had a great deal of work to prepare their lectures (and outlines, and post-lecture study questions) in the time available to them at NMSU. And with the limited time, there was not time to assign e.g., a homework assignment that students could work on for a week and then return to be graded by the CTF (as the CTF would have left campus by the time the homework assignment was due). However, as the CTFs all used some form of active learning, they did have the opportunity for informal formative assessment. The CTFs were also encouraged to write exam questions for their material, and the mentor provided feedback on those questions in terms of appropriateness (e.g., clarity, level, alignment with the learning objectives and teaching approaches, and time students would require to answer). Ultimately, while we recognize the importance and value of experience in developing and grading student assignments, we feel that our design already asks a lot of the CTFs, and that trying to add formal, graded assignments would not add to the experience.

Sparsely Attended Office Hours

The design included CTF office hours while at NMSU. As the CTFs are scientists still early in their careers, with graduate school and the graduate school application process not too far behind them, they have potentially relevant expertise beyond course content to share with students. In order to encourage students to take advantage of this expertise, the CTFs held office hours during their teaching week. Both the instructor and the CTF encouraged students to visit the CTF with any questions about course material or academic and career advice. While we do not have formal records of students visits, anecdotally at least a few students visited each CTF or contacted them by e-mail, and that the majority of these contacts were about academic and career advice. While students did not take full advantage of CTF office hours (nor did they take full advantage of the faculty mentor's office hours), we still think it is important for the CTF to be available to students outside of class time, and will continue to encourage students to engage with the CTFs outside of class. Office hours are one way to signal that the CTF is truly willing to connect with students.

Accepting Too Many CTFs in One Semester

One strategic error we made was by over-extending the design in a year during which we brought in three CTFs to the Introduction to Cancer course. The students had to contend with four teaching styles for the semester (the mentor and the three CTFs). There was also a little less continuity in the course that semester (as the three different CTFs had to try and synthesize their material with prior student knowledge and prior course material). In the end, we have found that one CTF in a course in a semester is probably ideal for students and mentor. We would still consider supporting two CTFs in a single semester (funds and interest permitting), but in that case we would place each CTF in a different course (e.g., one in the introductory biology course and one in the Introduction to Cancer course), to minimize continuity gaps in each course.

KEY ELEMENTS OF THE DESIGN

We feel that there were several critical aspects of our design that allowed it to be successful despite the challenges of distance and limited face to face time with the mentor and the students. One of these was the *sign-off and agreement by the research mentor* for their postdoc to participate in the program was critical to allow the CTFs to focus on their teaching during the residency. While the CTFs were not entirely "distraction free" (they still needed to carry out some level of research work, either checking in on the progress of experiments, analyzing data and/or preparing manuscripts), it is our impression that they had far more leeway to focus

on the teaching residency given their research mentor's "permission". In fact, we had several postdocs inquire about the program, and then either not apply, or withdraw their application because their research mentor was not willing to support their participation in the program and the time away from the lab.

Despite some of the challenges we experienced, we feel that the *extensive prep* is critical to the CTFs arriving on campus with a solid framework for their week of teaching. Even having clearly articulated learning goals and objectives and familiarity with active learning strategies is of huge benefit when finalizing the week of instruction.

Finally, we feel that the *intensive immersion* at NMSU is incredibly valuable. The CTFs are embedded in the biology department, they work closely with the teaching mentor, and observe many undergraduate courses in their first week. This immersion allows them to get a sense of the culture of the department, and a range of teaching styles to help inform their teaching plans. The practice teaching (end of the first week/beginning of the second week) is an incredibly valuable aspect of this experience. In virtually all cases, the CTFs extensively revised and re-practiced their lectures as a result of the practice teaching session.

CONCLUSIONS

Our design has allowed us to provide an intensive, mentored teaching experience to postdocs for whom such an opportunity is limited. We managed this despite a huge geographical separation between the postdocs and the teaching institution. As noted above, we feel that critical elements of our design include directed prep work and an intensive immersion during the teaching residency. Feedback from students has provided us with food for thought as we continue this program, and has provided a tangible product of the experience for the CTFs to use as they enter the academic job market. While the CTFs have been the primary targets of this program, students also express buy-in to this model. This is important, given that in our experience, students often resent being taught by "substitute" instructors or a "parade" of instructors in a single course. The successful immersion of the CTFs into the course is the result of the prep work, residency and focused work with the teaching mentor.

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